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ORIGINAL ARTICLE

Bifurcations of dust ion acoustic travelling waves in a magnetized quantum dusty plasma

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Abstract Bifurcation behavior of nonlinear dust ion acoustic travelling waves in a magnetized quantum dusty plasma has been studied. Applying the reductive perturbation technique (RPT), we have derived a Kadomtsev-Petviashili (KP) equation for dust ion acoustic waves (DIAWs) in a magnetized quantum dusty plasma. By using the bifurcation theory of planar dynamical systems to the KP equation, we have proved that our model has solitary wave solutions and periodic travelling wave solutions. We have derived two exact explicit solutions of the above travelling waves depending on different parameters.

Keywords Quantum dusty plasma · Bifurcation theory · Solitary wave · Periodic wave

1 Introduction

The classical plasmas are characterized by low densities and high temperature where as quantum plasmas are constituted by high densities and low temperature. Recently a remarkable interest has been drawn on quantum effects in plasma due to its wide domain of applicability. These important effects are quantum plasma echo (Manfredi and Feix 1996), quantum instabilities in Fermi gas (Manfredi and Haas 2001), quantum Landau damping (Suh et al. 1991), fabrication of semiconductor devices (Markowhich et al. 1990) quantum dots and quantum wires (Shpatakovskaya 2006) quantum wells, carbon nanotubes and quantum diodes (Ang et al. 2003, 2004; Shukla and Eliasson 2008). A several experiments have been carried out in dense plasma (particularly in astrophysical and cosmological studies) (Chabrier et al. 2002; Jung 2001), in dusty plasmas, in microelectronic devices (Markowhich et al. 1990), in nonlinear optics (Agrawal 1995) etc. to understand these effects on the behavior of linear and nonlinear wave propagations. Many authors have investigated quantum hydrodynamical model (QHD) to study the quantum effects. Obviously the QHD model is an extension of the classical fluid model in a plasma. The basic set of QHD equations analyzes the momentum and energy transport of the charged spices. The deviation from the classical model happens due to an additional term, the so called Bohm potential. This term contains Planck's constant h, indicates the quantum effect. Quantum effect is considered to be important when the thermal de Broglie wave length, ($\lambda_{B_\alpha} = \frac{h}{\sqrt{m_\alpha K_B T}}$ where m_α is the mass of the α-spices, K_B Boltzmann constant and h is Planck's constant, T is the system temperature) is similar to or larger than average inter particle distance. Since the de Broglie wave length depends upon the mass of the α particle, thermal energy $K_B T$ and mass of electron which is always less than that of ions, quantum effects regarding electron has more importance than the ions. On the other hand the effect is important where system temperature is comparable to or lower than the Fermi temperature $T_F = \frac{E_F}{K_B}$, where $E_F = \frac{h^2}{2m_e}(3\pi^2)^{2/3} n_e^{2/3}$ is the Fermi energy for electrons. So if $\chi = \frac{T_F}{T} = \frac{1}{2}(3\pi^2)^{2/3} n_e^{2/3} \geq 1$ then the quantum effects become important.

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