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ORIGINAL ARTICLE

Quantum electron-acoustic solitary waves interaction in dense electron-ion plasmas

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Abstract The effects of Bohm potential on the head-on collision between two quantum electron-acoustic solitary waves (QEASWs) in two electron species quantum plasma have been investigated using the extended Poincaré–Lighthill–Kuo (PLK) method. The analytical phase shifts after the head-on collision of the two QEASWs are derived. Numerically, in two cases (i.e., the dense solid state plasma and the dense astrophysical environments), the results show that the cold electron-to-hot electron number density ratio, the quantum corrections of diffraction and Fermi temperature of hot electrons have strong effects on the nature of the phase shifts and the trajectories of two QEASWs after collision.

Keywords Bohm potential · The head-on collision · Quantum electron-acoustic solitary waves · Extended Poincaré–Lighthill–Kuo method · Phase shifts

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1 Introduction

Recently, there have been several reports on nonlinear dynamics of electron-acoustic waves in electron–ion plasmas (Smain and Tribeche 2010; Pakzad and Tribeche 2011; El-Wakil et al. 2011; El-Shewy 2011). On the other hand, Quantum plasma, which has a very high electron number density and a low electron temperature in comparison with classical plasmas, is a new emerging and a rapidly growing subfield of plasma physics. In recent years, quantum plasmas have received much attention due to its important applications in solid state physics, microelectronics (Markowich et al. 1990), the self-consistent dynamics of Fermi gases (Manfredi and Haas 2001), quantum dots and quantum wires (Shpatakovskaya 2006), quantum wells, carbon nanotubes and quantum diodes (Ang et al. 2003, 2006; Ang 2004; Ang and Zhang 2007), ultra-cold plasmas (Killian 2006), dense astrophysical environments, such as the white dwarfs and neutron stars (Jung 2001) as well as in laser-produced plasmas (Kremp et al. 1999). It is well known that the quantum effect becomes important in plasmas, when de Broglie wavelength associated with the particles is comparable to dimension of the system. Recently, Haas et al. (2003) have described the quantum hydrodynamic model (QHD) for quantum ion-acoustic wave in electron–ion plasmas. The QHD model consists of a set of equations describing the transport of charge, momentum and energy in a charge particle system interacting through a self electrostatic potential. The QHD model generalizes the fluid model for plasmas with the inclusion of quantum correction term also known as Bohm potential. In addition, there are several reports on the nonlinear quantum acoustic waves characteristics in a quantum plasma (Garcia et al. 2005; Ali and Shukla 2006; Mahmood and Masood 2008; El-Labany et al. 2010a). Moreover, quantum electron-acoustic solitary wave