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ORIGINAL ARTICLE

Head-on collision of magnetoacoustic solitary waves in magnetized quantum electron-positron-ion plasma

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Abstract This article presents the first study of the head-on collision between two magnetoacoustic solitary waves (MASWs) in magnetized quantum plasma consisting of electrons, positrons, and ions, using the extended Poincaré-Lighthill-Kou (PLK) method. The effects of the magnetic field intensity, the positron to ion number density ratio, the quantum parameter, the Fermi temperature ratio, and plasma number density on the solitary wave collisions are investigated. It is shown that these factors significantly modify the phase shift.

Keywords Magnetized plasma · Soliton · Interaction

1 Introduction

In recent years, quantum plasmas have received a great deal of attention owing to their applications in dense astrophysical environments (Chabrier et al. 2002; Jung 2001; Opher et al. 2001), in microelectronic devices (Markowich et al. 1990), in intense laser beam produced plasmas (Kremp et al. 1999; Andreev 2000; Bingham et al. 2004; Marklund and Shukla 2006). In contrast to the classical plasmas, quantum plasmas are generally characterized by the low temperature and the high particles number densities. Quantum mechanical effects start playing a significant role when the average interparticle distance $a = (3/4\pi n)^{1/3}$ is comparable to or smaller than the thermal de Broglie wavelength $\lambda_B = h/mV_T$, where n is the number density, h is Plank's constant, m is the mass of the quantum particles, $V_T = (k_B T/m)^{1/2}$ is the thermal speed of the quantum particles, T is the temperature, and k_B is the Boltzmann constant (Masood et al. 2011; Masood and Siddiq 2011; Shukla and Eliasson 2012). In such situations, the plasma particles behave like a Fermi gas and quantum mechanical effects start playing a significant role in the dynamics of charged particles. Haas et al. have described the quantum hydrodynamic (QHD) model for quantum ion-acoustic wave in electron-ion plasmas (Haas et al. 2003).

The QHD model generalizes the fluid model for plasma with the inclusion of quantum statistics pressure and quantum diffraction (i.e., Bohm potential) terms. The electron-positron (e-p) plasma is considered to be the dominant constituent in the pulsar magnetosphere, neutron stars, quasars, and active galactic nuclei (Zank and Greaves 1995; Iwamoto 1993; Miller and Wiita 1987; Hirotani et al. 1999; Stenflo et al. 1985). The e-p plasmas dynamics, which consists of the same mass but oppositely charged particles, is quite different from electron-ion plasma (Stenflo et al. 1985; Rizzato 1988), in which both fast and slow time scales exist. Since in many astrophysical environments, there exist a small number of ions along with the electrons and positrons, the symmetry of e-p plasma dynamics breaks in the presence of ions. Much research has been carried out to study e-p and electron-positron-ion (e-p-i) plasma over the past few years (Lominadze et al. 1982; Gedalin et al. 1985; Berezhiani and Mahajan 1994; Mahajan et al. 1998; Popel et al. 1995; Nejoh 1996; Masood and Mushtaq 2008; Masood et al. 2010). Magnetoacoustic waves represent one

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