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ORIGINAL ARTICLE

Head-on collisions of ion-acoustic Korteweg-de Vries/modified Korteweg-de Vries solitons in a magnetized quantum electron-positron-ion plasma

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Abstract The head-on collisions of ion-acoustic solitary waves (IASWs) in a dense magnetized quantum plasma are investigated. The two-sided Korteweg-de Vries (KdV) equations in generic case as well as the two-sided modified Korteweg-de Vries (mKdV) equations in a special case are obtained, the analytical phase shifts and the trajectories after the head-on collisions of two IASWs in a three species quantum plasma are derived by using the extended version of Poincaré-Lighthill-Kuo (PLK) method for both the situations. We provide the theoretical predictions about the existence of compressive and rarefactive IASWs in the model. We observe that in generic case collisions are possible among the same polarity solitons, whereas in the special case collisions are possible among the same or opposite polarities solitons. Moreover the colliding phase shifts are significantly affected by the quantum diffraction parameter, by the square of the ratio of ion gyrofrequency to ion plasma frequency and by obliqueness of propagation. The important observations of this manuscript are that the waves reach a maximum amplitude which is the superposition of the initial amplitudes and they suffer a time delay during their collision. The plasma parameter values for white dwarfs are taken for discussion.

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1 Introduction

The linear and nonlinear wave propagation in classical electron-positron-ion (e-p-i) plasmas using verity of plasma models have been studied by several authors (Nejoh 1996; Mahmood et al. 2003; Tiwari et al. 2007; Saeed and Shah 2010). Recently the subfield quantum plasma of plasma physics is also enriched with various investigations (Haas et al. 2003; Ali and Shukla 2006; Shukla and Eliasson 2006; Ali et al. 2007a) on e-p-i plasma. Chatterjee et al. (2009) have been investigated nonlinear propagation of quantum ion acoustic waves in dense quantum plasma containing electrons positrons and positive ions using a quantum hydrodynamic model. It is noteworthy to mention here that when an e-p-i plasma is cooled to an extremely low temperature, the de Broglie wavelength of the charge carriers is comparable to the dimension of the system, and in such a situation, ultracold e-p-i plasma behaves like a Fermi gas and quantum mechanical effects are expected to play a vital role in the behavior of charged particles. Rasheed et al. (2010) concluded that only compressive ion-acoustic solitons can propagate in the three component Thomas Fermi plasmas whose constituents are degenerate electrons, positrons and classical ions but in our model although we considered degenerate electrons, positrons and classical ions, we find that both the compressive and rarefactive solitons are obtained depending upon the different parametric values.

When two oppositely directed solitary waves of same or different amplitudes are propagated with same or different velocities and come closure to each other the head-on collision (coined by Zabusky and Kruskal 1965) of