Impact of an External Magnetic Field on Solitary Waves in Quantum Electron-Hole Plasmas of Semiconductors

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The propagation of solitary acoustic pulses in magnetized quantum electron–hole plasmas of semiconductors has been studied. The effects of an external magnetic field and quantum terms, including the electrons and holes quantum recoil effects, exchange–correlation force, and the degenerate pressure of charge carriers are considered. Starting from quantum hydrodynamic equations, by using the reductive perturbation method, the Zakharov–Kuznetsov equation is derived. The theoretical model is applied to three types of semiconductors, namely GaAs, GaSb, and InP. It is clear that basic features of solitary acoustic waves are modified significantly by plasma parameters, especially number densities of semiconductors and magnetic field strength. The value of the amplitude and width of solitary waves strongly depends on the type of semiconductors and the propagation angle in a magnetized quantum electron–hole semiconductor plasma. Numerical results reveal that the width of the solitons gets reduced significantly with the increase of the magnetic field intensity while there is no effect on the amplitude of solitary waves. The weakest magnetic field that sets the pulse width to zero belongs to GaAs. Finally, the stability of the pulse soliton solution of the Zakharov–Kuznetsov equation has been discussed, analytically and numerically. The instability growth rate depends on plasma parameters and magnetic field intensity. The present paper can be meaningful in studying non-linear phenomena and instability behaviors in magnetized quantum electron–hole plasmas of semiconductors and the particle and energy transport mechanism in plasma-assisted quantum semiconductor nanodevices.

Keywords: quantum hydrodynamic model, reductive perturbation method, semiconductors, solitons.

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