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Study of nonlinear structures with relative density effects of spin-up and spin-down electrons in a magnetized quantum plasma

Nimardeep Kaur, Kuldeep Singh, Papihra Sethi and N. S. Saini
Department of Physics, Guru Nanak Dev University
E-mail: nimarphy@gmail.com

In the recent years, quantum or dense plasmas involving the collective interactions have drawn a great deal of attention of many researchers due to their wide range of potential applications in miniature semiconductor devices, metallic nana-structures and astrophysical objects[1-2]. Degenerate plasmas are found to play an important role in dense astrophysical objects like white dwarfs and neutron stars[3]. In such a plasma, the density is very high and the temperature is very low. The effects of strong magnetic field has not been the main focus of interest in degenerate plasmas. In fact, the presence of a strong ambient magnetic field[4] qualitatively changes the properties of atoms, molecules and condensed matter. Recently, a few attempts have been made to study the salient features of relativistic degenerate plasma, especially in the astrophysical plasma environment where such plasma conditions are prevalent. The electrostatic and electromagnetic waves have already been investigated by many researchers by considering the spin of fermions beside other quantum mechanical effects. It has also been revealed that the spin evolution in dense plasmas leads to the existence of new wave modes. The ion- acoustic waves (IAWs) are among the most well studied electrostatic modes in both linear and nonlinear regimes in dense astrophysical plasmas. Many plasma researchers investigated and studied the different features of low frequency waves in astrophysical dense quantum plasmas[5-6]. The spin oriented carriers are produced by injecting polarized particles by optical pumping which yields a high degree of spin polarization of electrons[7]. In the present investigation, the excitation and propagation characteristics of ion acoustic (IA) solitary waves are investigated in a dense magnetized plasma by employing the spin-evolution quantum hydrodynamic model. We have considered degenerate electrons having spin-up and spin-down relative density effects and non-degenerate cold ions. The Korteweg-de Vries equation is derived using the reductive perturbation technique and solved numerically to study the effect of various plasma parameters on the characteristics of ion acoustic solitary structures. The parametric role of the spin density polarization ratio on the amplitude and width of solitary structures is also investigated. The spin-up and spin-down polarization of degenerate electrons are considered via polarization index δ. The quantum tunneling effects are also taken into account by considering the Bohm potential term in the corresponding momentum equations of degenerate electrons. The numerical results obtained in the present investigation may be applicable to high density astrophysical regions such as white dwarfs and can also be helpful in understanding the properties of compact astrophysical objects where degenerate electrons, light nuclei and heavy nuclei are available. The findings may also be applicable to astrophysical plasmas (e.g., neutron stars/pulsars) where the spinning effect of fermions is included to describe the dense astrophysical plasma system.

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