Interaction between ion acoustic solitons in a quantum plasma with degenerate spin up and down electrons

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Dense quantum plasmas emerged as an active field of research due to their great pertinence in different areas of practical importance such as laser interactions with atomic systems, nanoscale electrochemical systems and in dense astrophysical plasmas such as white dwarfs[1]. In dense quantum plasmas, at extremely high number densities the de-Broglie wavelength associated with the charge particle becomes comparable to the inter-particle distance. The spin effects are considered as one of quantum plasma's most important properties due to great significance of highly magnetized quantum plasmas. The interaction of solitons is a phenomenon that usually occurs in various plasma environments. The way of interaction of two solitons can be assorted as head-on collision, overtaking and one of the noticeable attributes of solitons is that it conserves the shape andsize still after collision. After head-on collision, if pre (post)-collision part of soliton moves in front of the initial trajectory then phase shift is called as negative (positive) phase shift. The solitons exchange some energy between each other to preserve their shapes and sizes during head-on collision. The present work focuses on the study of head-on collision between ion acoustic (IA) multi-solitons propagating in opposite directions in a magnetized spin quantum plasma having inertial ions and degenerate electrons with spin-up and spin-down states. The separated spin evolution quantum hydrodynamic model is considered and the extended Poincaré-Lighthill-Kuo (PLK) method is adopted to derive two Korteweg-de Vries (KdV) equations. Further, the Hirota bilinear method is employed to determine the solitons solutions of two KdV equations for single-soliton, double-soliton and triple-soliton cases. The analytical expressions of phase shift after head-on collision of IA multi-solitons in different cases have also been derived. The combined effects of different physical parameters such as spin density polarisation, magnetic field and other physical parameters on the characteristics of IA solitons, time evolution and phase shift due to head-on collision between IA multi-solitons have been numerically described. It is seen from Figures (a) and (b) that spin density polarization ratio significantly affects the characteristics of ion acoustic multi-solitons as we move from strongly spin polarized case to zero spin polarized case. It is observed that the presence of spin density polarisation awfully affects propagation properties of IA solitons and phase shifts for different cases. The results of present investigation are useful to understand the nonlinear features of variety of nonlinear excitations in a dense astrophysical plasma region like white dwarfs.

References

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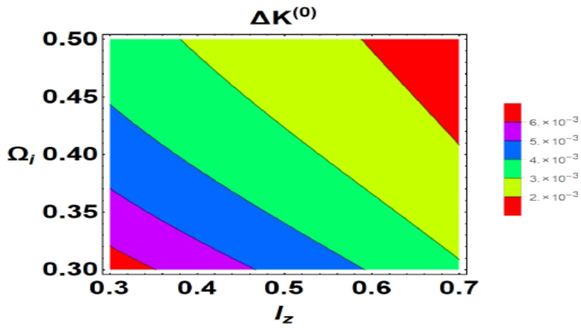
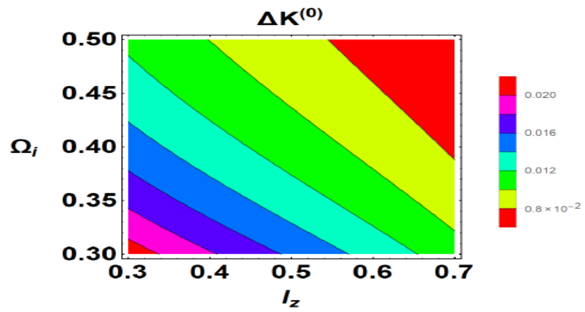


(a)



(b)

Figure1. The variation of phase shift $\Delta K^{(0)}$ vs direction cosine l_z for single-solitons collision for different values of Ω_i : (a) with (b) without spin density polarisation.