

Interaction of solitons for in quantum plasmas with relativistically degenerate electrons

Waqas Masood¹, M. Yousaf¹, R. Jahangir², N. Batool², M. Siddiq²

¹ Department of Physics, COMSATS University Islamabad, Islamabad Campus, ² National Center for Physics (NCP), Quaid-i-Azam University Campus, Shahdrah Valley Road, Islamabad, 44000, Pakistan.
e-mail: (waqasmas@gmail.com)

Using the quantum hydrodynamic model (QHD)^[1,2,3], nonlinear electrostatic waves on the ion time scale have been studied in a dense magnetoplasma in the presence of relativistically degenerate electron pressure effects^[4,5,6,7,8,9]. In this regard, acoustic type equations have been derived under the assumption of the weak turbulent theory. The single and two soliton solutions of these equations have been obtained by employing Hirota formalism^[10]. The non-relativistic and ultra-relativistic limits of the relativistically degenerate electrons have been studied both for the single and two soliton solutions of the acoustic type equations. We have applied our study for the plasma parameters that are found in the white dwarfs. It has been noticed that the interaction of the nonlinear structures depends on the propagation vectors in the predominant direction of propagation. Importantly, it has been found that the spatial and temporal scales over which the interaction of solitons occur are different for the non-relativistic and ultra-relativistic cases.

References

1. C. L. Gardner, C. Ringhofer, Phys. Rev. E. **53**, 157 (1996)
2. F. Haas, L. G. Garcia, J. Goedert, Phys. Plasmas. **10**, 3858 (2003)
3. N. L. Tsintsadze, L. N. Tsintsadze, EPL **88**, 35001 (2009)
4. S. Chandrasekhar S. MNRAS **170**, 405 (1935)
5. W. Masood, B. Eliasson, P. K. Shukla Phys. Rev. E. **81**, 066401 (2010)
6. W. Masood, B. Eliasson, Phys. Plasmas. **18**, 034503 (2011)

7. M Yousaf Khattak, W Masood, R Jahangir, M Siddiq, Waves in Random and Complex Media, 1 (2021)
8. R. Hirota, The Direct Method in Soliton Theory, Cambridge University Press (2004)

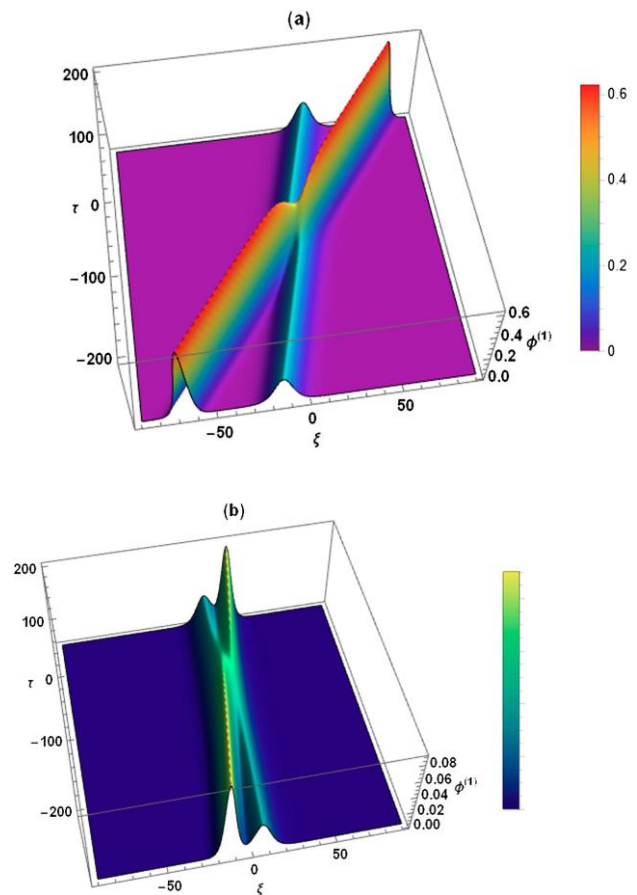


Figure (a): 3D plot of two solitons ion acoustic wave electrostatic potential $\phi^{(1)}(\xi, \eta, \tau)$ versus time τ and spatial coordinate ξ for $\eta=2$ fixed in non-relativistic limit. Other parameters are $k_1=0.50$, $k_2=0.30$, $n_{e0}=1 \times 10^{26} \text{cm}^{-3}$ and $B_0=2 \times 10^{11} \text{G}$.

(b): 3D plot of two solitons ion acoustic wave coordinate ξ for $\eta=2$ fixed in ultra-relativistic limit. Other parameters are $k_1=0.50$, $k_2=0.30$, $n_{e0}=1 \times 10^{31} \text{cm}^{-3}$ and $B_0=2 \times 10^{14}$.