Higher-order nonlinear contributions to ion-acoustic waves in a plasma consisting of adiabatic warm ions, non-isothermal electrons and a weakly relativistic electron beam

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Ion-acoustic solitary waves in a collisionless plasma consisting of adiabatic warm ions, a weakly relativistic electron beam [1, 2] and non-isothermal electrons [3, 4] are studied by using the reductive perturbation method. The basic set of model equations is reduced to a modified Korteweg-de Vries equation (mKdV) for the first order electric potential correction, and to a linear inhomogeneous equation for its second-order counterpart. Stationary solutions of the coupled equations are obtained by using the renormalization method of Kodama and Taniuti [5]. A better agreement between theory and experiments is obtained by taking into account the higher-order nonlinearity effects [6, 7].

The analysis reveals that four distinct ion-acoustic modes, which propagate at different phase velocities, occur in this plasma system. Two of these modes exist for all values of the electron beam to background electron density ratio α and ion to free electron temperature ratio σ. The amplitude of (mKdV) solitons decreases (increases) as α (σ, respectively) increases, while the inverse behavior is witnessed by the soliton width, for these two modes. On the other hand, the two remaining modes exist only for small values of α and high values of σ; in fact, the phase speed of these modes becomes complex at some range of values of α and σ. The amplitude and width associated to these modes decreases (increases) as α (σ, respectively) increases. Finally, it is remarked that the effect of higher order nonlinearity results in an increased soliton amplitude for one of these modes, while deforming the soliton's shape (from a simple positive pulse to a W-shaped excitation), while in the case of three other modes, the effect of higher-order nonlinearity is to increase the soliton's amplitude without deforming its shape (a simple pulse is obtained).

References

[1] Y. Nejoh, *J. Plasma Phys.* **56**, 67 (1996).

[2] A. R. Esfandyari, S. Khorram and A. Rostami, *Phys. Plasmas* **8,** 4753 (2001).

[3] H. Schamel, *J. Plasma Phys.* **9**, 373 (1973).

[4] S. G. Tagarel, *J. Plasma Phys.* **14**, 1 (1975).

[5] Y. Kodama and T. Taniuti, *J. Phys. Soc. Japan,* **45**, 298(1978)

[6] S. G. Tagare and R. V. Reddy, *J. Plasma Phy*s. **35**, 219 (1986)

[7] Y. Nakamura and H. Bailung, *Phys. Plasmas* **6**, 3466 (1999) .