Interaction of ion acoustic multi-solitons in an electron beam plasma

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The study of non-Maxwellian plasma is pivotal in understanding the dynamics of space and astrophysical plasmas. It has been indicated that the solar wind injects the electrons which drift in the upper layers of Earth's magnetosphere. These electrons tend to perturb the magnetospheric plasma and hence give rise to nonlinear wave structures and transform the conditions for the existence of solitary structures. Moreover, the observations of GEOTAIL spacecraft in the Earth's auroral region identifies that the broadband electrostatic noise in this region is associated with the nonlinear electrostatic solitary waves that might be related to the dynamics of electron beam instability. A number of observations have confirmed that high energy (superthermal) particles (electrons/ions) are present in most of the space and astrophysical environments. Such superthermal particles are adequately modelled by a kappa type distribution. It is also reported that kappa type distribution is more appropriate to model space data than the Maxwellian distribution. Superthermality of charged particles is measured with spectral index parameter. If spectral index parameters are large, superthermality of particles is small. Owing to the importance of presence of electron beam and superthermal particles in space/astrophysical environment, we have studied the head-on collision between two ion-acoustic solitary waves (IASWs) in unmagnetized plasma which comprises cold ion fluid, superthermal hot electrons, and penetrated by electron beam. By using the extended Poincaré-Lighthill–Kuo (PLK) perturbation method, two sided KdV equations are obtained. The Hirota direct method helps us to obtain multi-soliton solutions for each KdV equation, and they head towards the opposite direction and eventually the oppositely moving soliton overtakes each other's without changing the shape and amplitude. The expressions for collisional phase shifts after head-on collision of two, four, and six-(*IA*) solitons are also derived under the effect of penetration of electron beam. The combined effects of an electron beam and variation in other physical parameters on the properties of IASWs during head on collision have been analyzed. It is remarked that beam components and other plasma parameters significantly influence the phase shifts and other properties of IASWs in the given plasma system. Further, it is observed that in the absence of beam parameter and very large value of spectral index parameter, our results agree with investigation of Maxwellian plasmas. The findings of this investigation might be useful to understand the nonlinear excitations in different space and astrophysical plasma environments which contain superthermal charged particles and are penetrated by an electron beam.

References

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