Head-on Collision between Multi-solitons in relativistic plasma

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Over the last few decades, studies on the nonlinear propagation of electron acoustic waves (EAWs) have received a great deal of interest. Electron acoustic waves are high frequency electrostatic waves. The study of these kind of waves can be explained when we consider the plasma consisting of one hot electron species along with the cold electrons in the stationary background of ions [1]. Here, the restoring force comes from the thermal pressure of the hot electron species and inertia is provided by the cold electrons. As this acoustic mode is highly Landau damped, still it exists even when the equilibrium density of hot electrons is considered to be larger than the equilibrium density of cold electrons and $T_c << T_h$, where T_c and T_h are the temperatures of hot and cold electrons respectively. The study of electron acoustic waves has been performed mostly in the non-relativistic and weakly relativistic limits. The significance of considering the relativistic dynamics of electrons arises due to the fact that the effect of relativistic streaming electrons on the large electric field observed in the polar cusp regions of the pulsar magnetosphere can make the cold electron species to achieve relativistic velocities. The effect of relativistic nonlinearity is related with the relativistic mass variation of electrons on EAWs has been recognized in several astrophysical situations, e.g., galactic and extragalactic jet accretion disks of active galactic nuclei, and also in laboratory tokamak plasmas. The relativistic effects arise due to the streaming of electrons on the solitary structures [2]. Most of the space and astrophysical environments confirm the existence of superthermal particles which is modeled by kappa distribution function. It is believed that kappa distribution is more appropriate to fit the data of the different satellite missions obtain from the space/astrophysical observations. In most of plasma environments, the wave-waves interaction is a leading non-linear phenomenon. It is divided on the basis of inverse scattering and a head-on collisions. The head-on collisions may provide two effects. i.e; phase shifts and trajectories. A theoretical investigation is carried out to study head on collisions among multi electron acoustic solitons (EASs) in the unmagnetized superthermal relativistic plasma containing two temperature electrons (cold inertial and hot) and stationary ions. By employing extended Poincaré-Lighthill-Kuo method, two Korteweg-de Vries (KdV) equations are derived. The Hirota direct method [3] is used to obtain multisoliton solutions for each KdV equation and all of them move along the same direction where the fastest moving soliton eventually overtakes the others. The analytical phase shift after a head-on collision of EASs are also obtained. We have analyzed the influence of different plasma parameters on the phase shift occurred after the interaction of multi-solitons. Our findings may have applications in understanding a head-on collision between two electron acoustic solitons waves (EASs) in astrophysical and labortary plasmas, especially Van Allen radiation belts, plasma sheet boundary layer of Earth's magnetosphere and pulsars, etc.

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