ABSTRACT

Nonlinear ion acoustic (IA) and electron acoustic (EA) waves in e-p-i and electron beam plasmas, respectively, have been studied in this thesis to elucidate the effect of full velocity distribution profile on the propagation characteristics of such electrostatic waves. For this we have employed three different distributions in our theoretical models, classical Maxwellian distribution, kappa distribution and generalized (r, q) distribution. Kappa distribution characterises Maxwellian distribution at low energies but exhibits high energy tail as compared to the Maxwellian distribution for low values of kappa, i.e. $\kappa \to 3/2$ and approaches to Maxwellian tail as $\kappa \to \infty$. However, generalized (r, q) distribution exhibits flat top and spikes at low energies and non-Maxwellian tail at higher energies. The generalized (r, q) distribution tends to become kappa distribution when $r = 0, q = (\kappa + 1)$ and $r = 0, q \to \infty$. The aim of this thesis is to study the propagation of nonlinear electrostatic waves in multispecies plasmas by mainly employing the generalized (r, q) distribution since it has the advantage that it mimics most of the distribution functions observed in space plasmas.

Nonlinear IA waves have been studied for three different cases when; (I) electrons are considered (r, q) distributed and positrons as Boltzmannian, (II) electrons are considered (r, q) distributed and positrons as kappa distributed and (III) both electrons and positrons are modelled by (r, q) distribution. Nonlinear EA wave has been studied in an electron beam plasma which is comprised of cold and hot electrons where hot electrons have been assumed to follow the generalized (r, q) distribution. For the case-I, in the small amplitude limit we found that amplitude of the soliton turns to be maximum for the Druyvesteyn-Davydov distribution when $r > 0, q \to \infty$ which corresponds to the flat top distribution with Maxwellian tail and remains minimum for kappa distribution. For the arbitrary but finite amplitude solitary structures we found that for the positive values of r, which corresponds to the flat top distribution, we only obtained the compressive solitary structures both in subsonic and supersonic regimes. However, for the negative values of r, which corresponds to the spiky distribution, we obtained rarefactive solitary structures in the supersonic regimes but both compressive and rarefactive solitary structures at the same time in the subsonic regime. For the case-II, in the small amplitude limit, our results showed that the maximum amplitude of solitons turns out to be large for larger values of r and q

for electron distribution which correspond to the flat top nature of distribution and remains minimum for kappa distribution. For the arbitrary but finite amplitude solitary structures we found simultaneous presence of compressive and rarefactive solitons for negative value of r which could not be found in small amplitude limit. However, similar to KdV solitons, we found that polarity of soliton switches from compressive to rarefactive as we increase the negative value of r. For the case-III, we only studied IA solitary waves in small amplitude limit and found that compressive soliton amplitude remains maximum for positive values of r and increases as r increases for either positron or electron distribution which corresponds to the flat top distributions. It has also been found that polarity of the soliton changes from compressive to rarefactive for certain negative values of r.

For the nonlinear EA waves comprising of cold and hot electron populations in which hot electrons have been assumed to follow the generalized (r, q) distribution. We found that with the increase of either of the spectral index r or q, rarefactive soliton becomes taller as well as its width increases. Also soliton remains taller for the case of (r, q) distribution than the soliton for the cases of Maxwellian and kappa distributed plasmas. Moreover, for the negative values of r which correspond to the spiky distribution, we obtained both compressive and rarefactive solitons in contrast to the kappa distributed and Maxwellian plasmas.

The results presented in this thesis are novel and very interesting as IA (EA) nonlinear waves admit not only compressive (rarefactive) structures but also allow the formation of rarefactive (compressive) solitary structures for the generalized (r, q) distribution which are not possible when we employ Maxwellian and kappa distributions. Moreover, the results presented in this thesis elucidate the fundamental understanding of the complete profile of the distribution function, high as well as low energy parts, in the formation of compressive and rarefactive small and arbitrary amplitude solitons in both space and astrophysical plasmas, which could not possible otherwise.