ABSTRACT

Plasmas, more often than not, have more than one species of electrons and ions. Some examples of such multi-species plasmas are the beam plasma systems, turbulent plasmas of thermonuclear interest, solar wind near 1 AU, fusion plasmas with impurities, magnetospheric plasmas, etc. But most of the theoretical work dealing with these systems consider the plasma to have one species of electrons and one species of ions only. However, some recent theoretical investigations have shown that the presence of more than two species of particles can
change the dispersive properties of the medium rather drastically. For example, only compressive ion acoustic solitary waves (solitons or density humps) exist in a single electron component plasma, whereas, rarefactory ion acoustic solitary waves (holes or density dips) also can exist when the presence of a second electron species is taken into account. Similarly, electron acoustic (EA) holes also can occur, in addition to the EA solitons, if the plasma consists of more than one species of ions. So, in order to obtain correct information about the processes occurring in such multi-species-plasmas, it is only proper that all the particle species be taken into account.

In this thesis we have considered the multispecies plasmas and have investigated the existence and propagation of solitary ion acoustic waves, solitary ion cyclotron waves, EA waves, ion-ion-hybrid-resonance (IIHR) waves, the drift instability of EA and IIHR waves and the possibility of mode conversion between the EA and IIHR waves. As regards the ion acoustic waves, in a two electron component plasma both solitons and holes can occur even when the ions are cold. However when the finite temperature of the ions is appropriately accounted for, we find that the maximum amplitude of solitons as well as holes is reduced significantly. Finite ion temperature also reduces the allowed regions (regions in parameter
space where solitons and holes occur); in some cases the holes are even forbidden. When two species of electrons are present in a magnetoplasma, in addition to the rarefactory electrostatic ion cyclotron solitary waves, which exist in a single electron component plasma, a new type of solitary wave, namely, the compressive solitary wave can also occur. The allowed regions for the existence of these solitary waves are greatly affected by any change in the ion temperature and the ratio of density and temperature of the hot and warm electron components. The formation of the pulsed perpendicular electrostatic shocks observed in the auroral plasmas at an altitude of \( \sim 1 \text{ Re} \) can be nicely explained in terms of these EIC solitary waves only if the presence of the second electron species is taken into account. An ion acoustic envelope soliton propagating in a two-electron-species inhomogeneous plasma, with the density gradient scalelength of the order of the width of the envelope soliton, is found to split into two solitary waves. However, the splitting time is longer compared to the one in a single electron species plasma. Furthermore, the splitting of the envelope holes in a two-electron-component plasma is found to be delayed so much that splitting does not occur within a practical length of time.
In a magnetised plasma with ions more energetic than the electrons, electron acoustic waves can propagate in a direction almost perpendicular to the magnetic field. If more than one species of ions are present in the plasma, the ion-ion-hybrid resonance mode also is excited. The effect of any change in the relative concentration, mass and temperature of the two ion species on the characteristic frequencies of the electron acoustic and the ion-ion-hybrid resonance modes in the magnetospheric plasmas and the 2XIIB mirror machine is studied. The presence of weak density gradients perpendicular to the magnetic field and the direction of wave propagation, gives rise to drift waves. Coupling of these drift waves with the electron acoustic ion-ion-hybrid resonance waves can give rise to the corresponding drift instabilities. The range, over which these drift instabilities occur is larger when the medium has stronger inhomogeneities. The presence of density gradients, in principle, can lead to mode conversion between the EA and IIHR waves. But within the approximation of fluid theory and in the limit of weak inhomogeneities, it is found that mode conversion between the EA and IIHR waves does not occur in the magnetospheric plasmas or in the 2XIIB mirror machine.