Preface

Dust is quite common throughout the universe and represents much of the solid matter in it. On the other hand, the gaseous component of matter is often ionized (at least partially), and thus dust coexists with plasma and forms a "dusty plasma" (Goertz, 1989). In recent years there has been a growing interest in the study of dusty plasmas. The characteristic frequencies of the dust particles are even smaller than the corresponding ion frequencies. We have therefore studied in this thesis the influence of dust particles on the electromagnetic ion cyclotron (EMIC) waves in a plasma where the ions (protons) are modelled by a generalised bi-Lorentzian (Kappa) distribution or a Maxwellian distribution.

Plasmas occurring naturally in space are generally non- Maxwellian; they are often characterised by an energetic tail distribution (Vasyliunas, 1968 and Williams et al 1988). A useful distribution function to model such plasmas is the generalised Lorentzian or Kappa distribution. The well known Maxwellian and Kappa distributions differ substantially in the high energy tail region; the drop towards zero is much more abrupt for a Maxwellian distribution when compared to that of a Kappa distribution with a low spectral index κ. This difference is however less significant as κ increases. When compared to the particles with a Maxwellian distribution, such high energy particles can enhance the growth of plasma waves, especially when the phase velocity of the wave is large compared to the thermal bulk velocity of the plasma. Such conditions commonly occur in space and other magnetospheric plasmas and Kappa distributions have been used to analyse and interpret spacecraft data in the Earth's magnetospheric plasma sheet (Vasyliunas, 1968 and Williams et. al. 1988), the solar wind (Abraham - Shrauner et. al. 1979, Church and Thorne, 1983), Jupiter (Leubner, 1982) and Saturn (Armstrong et. al., 1981). In fact it has been found that, in practice, many space plasmas can be modelled more effectively by a superposition of Kappa distributions than by Maxwellians.

The thesis is organised as follows:

Chapter 1 gives a brief explanation about " Dusty Plasma" and its occurrence in space plasmas. We then report some properties / characteristics of dusty plasmas such as dust charging and dust dynamics and review the basic theory of waves and instabilities in a plasma and then waves and instabilities in dusty plasmas. Finally we touch upon the recent studies on wave propagation and instabilities in dusty plasmas.

In Chapter 2 we study the influence of dust particles on electromagnetic ion cyclotron waves propagating parallel to the magnetic field in a plasma where the hot ions are described by a bi-Lorentzian or Kappa distribution; the other components of the system being electrons and negatively charged dust particles; these are treated as cold. The electrons have been treated as "cold" since they mask important effects due to ions and dust particles when modelled kinetically. We also consider the stability of these waves in both low - and high - β plasmas. Expressions for the dispersion relations and growth rates were derived for both the low - and high - β cases. We find that in low - β plasmas the growth increases with temperature anisotropy of the ions, the charge number Z_D of the dust particles and density ratio of the dust particles to the ions n_D/n_i. However, in high - β plasmas the growth rate exhibits a mixed behaviour as regards the charge number Z_D and n_D/n_i. The growth rate is independent of the mass ratio m_i / m_D, for both the cases at least for the massive dust particles.

In Chapter 3, we study a zero frequency mode in both high - β (applicable to the disturbed conditions of the solar wind) and low - β (for quiet conditions of the solar wind) plasmas. We have derived expressions for the zero frequency mode in both the high - and low - β plasmas, treating ions, electrons and dust as described in Chapter II. For the low - β case, temperature anisotropy is the source of instability; the instability is, however, restricted to a very narrow temperature anisotropy range of the hot ions. The instability of the mode is independent of the parameters of the dust. However in high - β plasmas, the stability is strongly influenced by the dust; the growth/ damping rate depending on the product of the charge on the dust and its density.

In Chapter 4, we have studied the stability of EMIC waves, propagating parallel to the magnetic field, in a plasma where the two ion components modelled by bi-Lorentzians are drifting relative to each other. The other components that make up the plasma are dust particles and electrons. As in Chapter II, we find that the dust particles have an appreciable effect on the growth rate of the IC waves only when the plasma - β is very low. In a low - β plasma the growth rate increases with increasing temperature anisotropy of the hot ions, charge number and density of the dust particles and drift velocity of the drifting component. The growth rate, however, decreases with increasing drifting ion densities. In a high - β plasma, however, the ion cyclotron mode is, in general, damped at the higher frequency end.

In Chapter 5, we choose the well - known anisotropic Maxwellian distribution to model the hot ions; again the electrons and dust particles are treated as cold. We study the convective instability of the IC waves, propagating parallel to the magnetic field, with the wave vector k complex ($k = k_r + ik_i$) and ω is kept real. We find that temperature anisotropy is the source of the instability for both the low - and high - β plasmas. However both the charge number Z_D and density n_D of the dust particles have marked influences on the growth rate only in the high - β case.

In Chapter 6, we study some aspects of the electron branch of the propagation of electromagnetic waves in plasmas in which electrons are described by bi-Lorentzian distributions. We study the convective instability of electromagnetic waves in a two - component bi-Lorentzian plasma. When the plasma - β of the electrons is large the instability, which is restricted to the frequencies below the electron gyro-frequency, is driven by temperature anisotropy in a one component plasma. A "stationary", second electron component suppresses this instability; however when this component has a finite drift velocity, the wave growth is increased. The wave growth drops sharply when the spectral index κ is increased; it , however, tends to saturate when κ increases beyond a certain value. When the plasma - β of the electrons is low we find that the range of the wave growth increases with increasing value of the temperature anisotropy ratio. However, what is more interesting is that, in contrast to the high - β case, the region of the wave growth increases with increasing κ.

A major part of the work included in this thesis has been published / communicated in the following journals or presented at the Conferences given below:

Research papers published / communicated to journals

1. The influence of dust particles on electromagnetic ion cyclotron waves in a bi- Lorentzian plasma.
   Chandu Venugopal, K. John Varughese, S. Antony, C P Anilkumar and G.Renuka , Phys. Plasmas (September, 1997).

2. A dust influenced zero frequency instability in a bi-Lorentzian plasma.
   Chandu Venugopal, K. John Varughese, S . Antony, C.P.Anilkumar, and G. Renuka, (1997) (Under revision).

3. Influence of dust on ion cyclotron waves in a two ion plasma.
   Chandu Venugopal, K. John Varughese, S. Antony, C.P.Anilkumar, and G.Renuka (1997) (Communicated).

4. A part of (3) has been published in Proceedings of the Fifth International School / Symposium for Space Simulations, Radio Atmospheric Science Center, Kyoto University, Japan, March 13 - 19, pp 357- 360.

5. Convective instability of ion cyclotron waves in a dusty plasma.
   K. John Varughese, Chandu Venugopal, S. Antony, C.P Anilkumar and G. Renuka (1997) (Communicated).

6. A temperature anisotropic instability in a two component bi-Lorentzian plasma,
   John K. Varughese, S. Antony, M.J. Kurian, Chandu Venugopal and G.Renuka, Ind. J. Phys. **71B** (4), 485, 1997.

Paper presented in International Conferences

1. The influence of Dust particles on Electromagnetic ion cyclotron waves in a bi-Lorentzian plasma.
   Chandu Venugopal, K. John Varughese S. Antony, C.P. Anilkumar, G.Renuka and N.Balan, The Fifth International School / Symposium for Space Simulations, Radio Atmospheric Science Center, Kyoto University, Japan, March 13-19, p357.

Papers presented in National Conferences

1. Instabilities of electromagnetic waves in a two component plasma with high energy distribution.
   K. John Varughese, S.Antony, M J Kurian, Chandu Venugopal and G. Renuka. Paper presented at National Space Science Symposium, NSSS-96, February 6 -10, 1996, p62.

2. Low frequency dust driven instabilities in a bi-Lorentzian plasma.
   K. John Varughese, S.Antony, C P Anilkumar, Bindu P M, Chandu Venugopal and G. Renuka, Paper presented at PLASMA - 96, October 28 - 31, 1996, p79.