



## Drift Wave Instability With kappa Distribution Function in Magneto plasma by Particle aspect analysis

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### 1. Basic Assumptions

We consider the two potential component of electric field a Drift wave of the form

$$\begin{aligned} E &= E_{\perp} + E_{\parallel} = -\nabla \phi \\ \phi &= \phi_1 \cos(k_{\perp} Y + K_{\parallel} Z - \omega t) \end{aligned} \quad (1)$$

Where  $\phi_1$  is a slowly varying function of time, and  $\omega$  is the wave frequency which is assumed as real.  $k_{\perp}$  and  $K_{\parallel}$  define the components of wave vector across and along the static and magnetic field  $B_0$ . The wave is assumed to start at  $t=0$  when the resonant particle are not yet disturbed. The main interest line in the behavior of drift wave which satisfy the plasma condition

$$V_{T\parallel i} \ll \frac{\omega}{-KI} \ll V_{T\parallel e}, \omega \ll \Omega_i \Omega_e; K_{\perp}^2 P_i^2, k_{\perp}^2 P_d^2 \ll 1 \quad (2)$$

Where  $V_{T\parallel i}$ ,  $V_{T\parallel e}$  are the mean velocity of ion and electron and particle along the magnetic field  $B_0$ ,  $\Omega_{ied}$  are cyclotron frequencies and  $p_{ied}$  the mean radius of the respective species  $K_{\perp}$  and  $K_{\parallel}$  are the components of real wave vector h perpendicular and parallel to the magnetic field,

## 2. Distribution Function:

We consider bi Lorentzian distribution function as by Ahirwar et al.(2012). The Lorentzian which reduces to the anisotropic maxwellian distribution when the spectral index  $\kappa$  tends to infinity is given by Ahirwar et al.(2012)

$$F_x(V) = \frac{1}{\pi^{3/2}} \frac{\Gamma(\kappa-1)}{\kappa^{3/2} \Gamma(\kappa-1/2) V_{T\perp}^2 V_{T\parallel e}^2} \left[ 1 + \frac{V_{\perp}^2}{K_{\perp} V_{T\perp}^2} + \frac{v_{\parallel}^2}{K_{\parallel} V_{T\parallel e}^2} \right]^{-(\kappa+1)}$$

In eq.(4)  $V_{T\perp}$  and  $V_{T\parallel e}$  are thermal velocity related to the mass  $m$  and the temperature  $T_{\perp}$  and  $T_{\parallel e}$  respectively parallel and perpendicular to the magnetic field  $B_0$

$$V_{K_{\perp} T_{\perp}}^2 = \left[ \frac{\kappa - 3/2}{\kappa} \frac{2K_{\perp} T_{\perp}}{m} \right] \quad \text{And}$$

$$V_{K_{\parallel} T_{\parallel e}}^2 = \left[ \frac{K - 3/2}{K} \frac{2K_{\parallel} T_{\parallel e}}{m} \right]$$

The  $\kappa$  Lorentz kappa distribution has been introduced as more suitable for modeling magnetized plasma

## 3. Dispersion Relation

To evaluate the dispersion relation we calculate the integrated perturbed density for non resonant particle as

$$\overline{n_{ie}} = \int_0^{\infty} 2\pi V_{\perp} dV_{\perp} \int_{-\infty}^{\infty} dV_{\parallel} n_i(r, t) \quad (3)$$

With the help of eqs(3) and (8) we find the average densities for homogenous plasma as

$$\overline{n_i} = \frac{N_e e \phi}{T_{\perp i}} C_4 \left\{ a_i - \frac{K_{\perp} v_{di}}{\omega} F_i Z_R(f_i) + \frac{T_{\perp i}}{T_{\parallel i}} (1 + f_i Z_K(f_i)) \right\} \quad (4)$$

.

$$\overline{n_e} = -\frac{N_e e \phi}{T_{\perp e}} \quad (5)$$

Where

$$q_i = \frac{1}{2K_{\perp}^2 e_i^2}, f_i = \frac{\omega}{K_{\parallel} V_{T\parallel i}} \gg 1$$

And  $V_{di} = T_{\perp}/m\Omega \left( \frac{1}{N} \frac{dN}{dX} \right)$  is the diamagnetic drift velocity

It is observed that essential feature of the drift wave is retained even in this ideal case.

For Maxwell's equation we use the quasi-neutrality condition

$T_{\perp}$  and  $T_{\parallel}$  are the temperature perpendicular and parallel to the magnetic field respectively

$$C_K = \int_0^{\infty} \frac{K_{\perp} V_{di}}{\Omega_i} f_{\perp k}(V_{\perp}) 2\pi V_{\perp} dV_{\perp} = \left\{ 1 - \left( \frac{2\kappa - 1}{2\kappa - 3} \right) a_i \right\} \quad (6)$$

$$Z_K(\xi) = \frac{1}{\sqrt{\pi} k^{1/2}} \frac{\Gamma k}{\Gamma k - 1/2} \int_{-\infty}^{+\infty} dx \frac{\left( 1 + \frac{x^2}{k} \right)^{-(k+1)}}{(x - y)} \quad (7)$$

For a non Maxwellian plasma characterized by the kappa distribution function ( $\kappa$ ) Summers and thorne (1991) have derived a modified plasma dispersion relation

$$\bar{n}_i = \bar{n}_e + Z_d n_d$$

Substitution equation (4) and equation (5) in 667assion's equation

We obtained the dispersion relation P.Varma and M.S Tiwari (1992)

$$\omega = \frac{K_{\perp} T_{\perp e}}{T_{\perp e}} K_{\perp} V_{de} \left[ 1 - \frac{(2\kappa - 1)}{(2\kappa - 3)} K_{\perp}^2 \rho_i^2 \left( 1 + \frac{T_{\perp e}}{T_{\perp e}} \right) \right] \quad (8)$$

Note that  $V_{de} > 0$  for  $\frac{\partial N}{\partial x} < 0$  as defined

The phase velocity of the drift wave across the magnetic field,

$\frac{\omega}{K_{\perp}}$  is nearly equal to the electron pressure drift velocity

#### 4. Growth Rate:

Evaluating the wave energy density per unit wave length and the change in the energy of non resonant and resonant particle has calculate the growth rate

From,

$$\frac{1}{\phi_1} \frac{d\phi_1}{dt} = Y \quad (9)$$

$$Y = \frac{1}{\phi_1} \frac{d\phi_1}{dt} = \pi \omega \frac{T_{\perp e}}{m_e} \left\{ \frac{K_{\perp} V_{de}}{K_{\perp} \left( \frac{T_{\perp e}}{m_e} \right)} f_{k\perp e} \left( \frac{\omega}{k_{\perp}} \right) + f_{k\parallel e} \left( \frac{\omega}{k_{\parallel}} \right) \right\} \quad (10)$$

Substuting equation (1) we finally obtain the growth rate of drift wave as

$$\frac{Y}{\omega} = \frac{\sqrt{\pi}}{2k^{1/2}} \frac{\Gamma k}{\Gamma \left( k - \frac{1}{2} \right)} K_{\perp} \left( \frac{2T_{\perp e}}{me} \right)^{1/2} \left[ \frac{T_{\perp e}}{T_{\perp e}} \frac{K_{\perp} V_{de}}{\omega} - 1 \right] \times \left[ 1 + \frac{\omega^2 m_e}{2k_{\perp}^2 T_{\perp e}} \right]^{-(k+1)} \quad (11)$$

The K Lorenz distribution has been introduced as more suitable for modeling magnetized plasma . Here it is noticed that the kappa distribution function has affected the growth rate for the drift wave.

## 5. Growth Length:

The formula for the adopted growth is given as

$$V_g = \frac{\frac{\partial D}{\partial K}}{\frac{\partial D}{\partial \omega}} = \frac{\partial \omega}{\partial K} = D \quad (12)$$

$$D = \frac{\partial \omega}{\partial K_{\perp}} = V_g$$

$$V_g = \frac{T_{\perp e}}{T_{\perp e}} k_{\perp} V_{de} \left[ 1 - \left( \frac{2k-1}{2k-3} \right) K_{\perp}^2 \rho_i^2 \left( 1 + \frac{T_{\perp e}}{T_{\perp e}} \right) \right] \quad (13)$$

$$Y_L = \frac{V_g}{Y}$$

$$Y_L = \frac{\frac{T_{\perp e}}{T_{\perp e}}}{\frac{1}{2k^{1/2}}} \frac{k_{\perp}}{\Gamma k - 1/2} \frac{\omega}{k_{\perp} \left( \frac{2T_{\perp e}}{me} \right)^{1/2}} \left[ \frac{T_{\perp e}}{T_{\perp e}} \frac{k_{\perp} V_{de}}{\omega} - 1 \right] \times \left[ 1 + \frac{\omega^2 me}{2k_{\perp}^2 T_{\perp e}} \right]^{(k+1)} \quad (14)$$

Where  $V_g$  is the group velocity of the waves

Here it is noticed that  $k$  has affected the growth length for the drift wave propagating perpendicular to the magnetic field

## 6. Result and Discussion:

The following inospheric plasma parameter have been used for the evalution of the growth rate , growth length and dispersion relation of the drift wave ,

$$\frac{1}{N} \frac{dN}{dX} = 10^{-5} m^{-1}, K_{\perp} = 5 \times 10^{-8} m^{-1}$$

$$e_i = 3m \quad \Omega_i = 160 s^{-1} \quad T_e = 500^\circ K$$

$$\Omega_e = 8.4 \times 10^6 \text{ sec}^{-1} \quad V_{de} = 0.85 \times 10^{-2} m/s$$

$$V_{Ti} = \left( \frac{2KT_i}{mi} \right)^{1/2} = 4.8 \times 10^{-2} m/s$$

$$V_{Te} = \left( \frac{2kT_e}{me} \right)^{1/2} = 1.2 \times 10^5 m/s$$

$$k_{\perp} = 10^{-1} - 10^{-3} m^{-1}$$

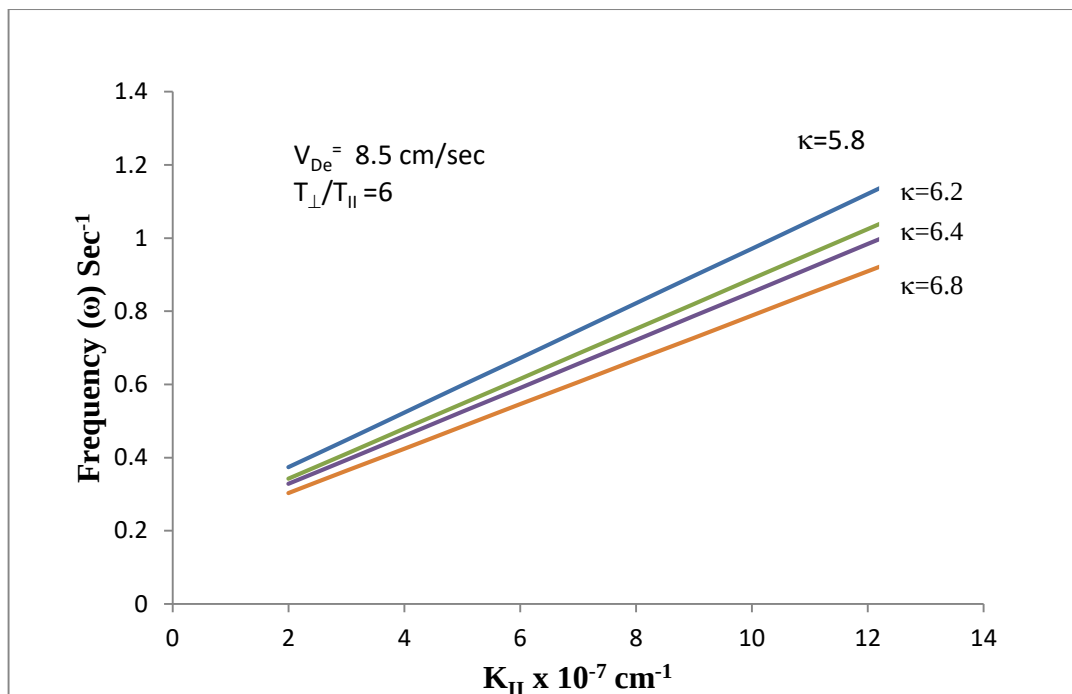


Fig. 2.1 The variation of real frequency ( $\omega$ )  $\text{sec}^{-1}$  versus wave vector ( $K_{II}$ )  $\text{cm}^{-1}$  for different values of kappa distribution function ( $\kappa$ ) at drift wave velocity  $V_{De}$  &  $T_{\perp}/T_{\parallel}=6$ .

Shows the relation between variation of real frequency ( $\omega$ )  $\text{sec}^{-1}$  versus wave vector ( $K_{II}$ )  $\text{cm}^{-1}$  for different values of kappa distribution function ( $\kappa$ ) at drift wave velocity  $V_{De}$  &  $T_{\perp}/T_{\parallel}=6$ . It is observed that real frequency( $\omega$ ) increases with increasing in wave vector( $K_{II}$ )

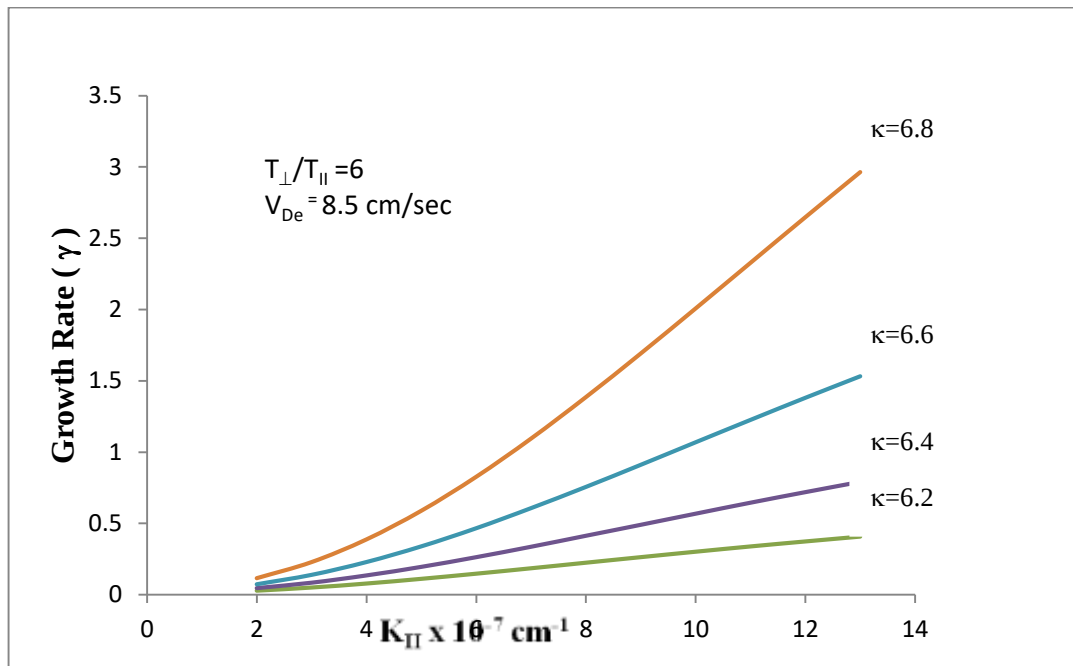


Fig. 2.2 The variation of growth/ damping rate ( $\gamma$ ) versus wave vector ( $K_{II}$ )  $\text{cm}^{-1}$  for different values of kappa distribution function  $\kappa$  at drift wave velocity  $V_{De}$  &  $T_{\perp}/T_{\parallel}=6$ .

The relation between of growth/ damping rate ( $\gamma$ ) versus wave vector ( $K_{II}$ )  $\text{cm}^{-1}$  for different values of kappa distribution function  $\kappa$  at drift wave velocity  $V_{De}$  &  $T_{\perp}/T_{\parallel}=6$ . It is observed that the growth rate ( $\gamma$ ) enhanced wave vector its clear that the growth/ damping rate ( $\gamma$ ) increases with increase of wave vector ( $K_{II}$ ) the increase of damping rate ( $\gamma$ ) with increasing ( $K_{II}$ )

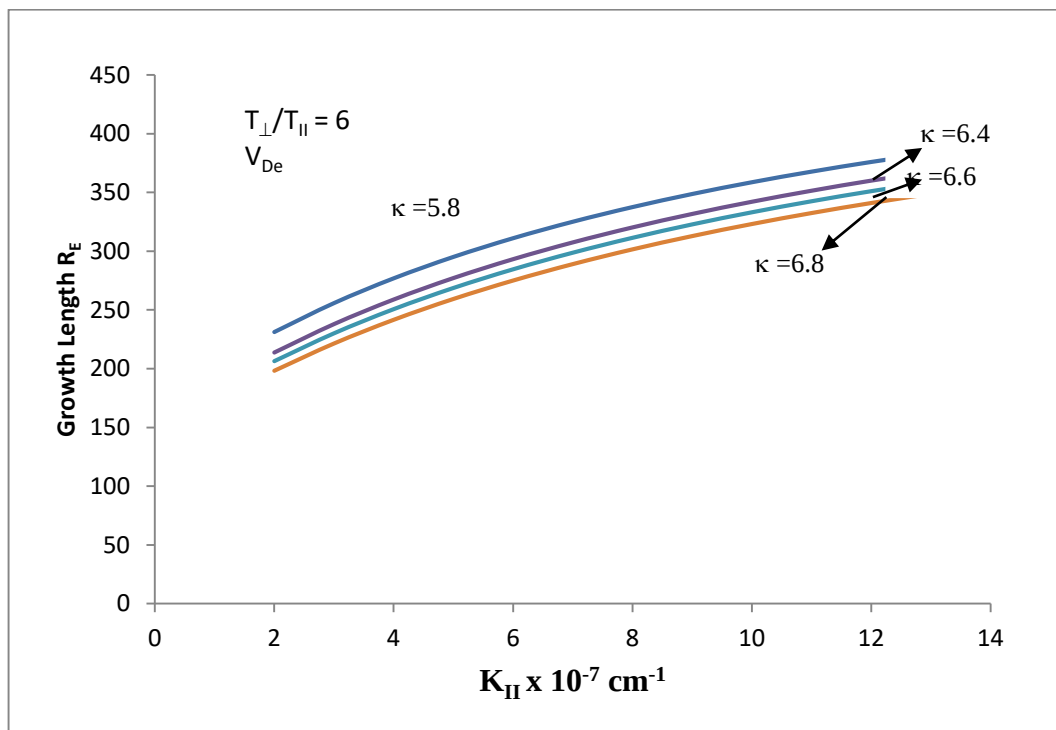


Fig. 2.3 The variation of growth length  $(\gamma_L) R_E$  versus wave vector  $(K_{II}) \text{ cm}^{-1}$  for different values of kappa distribution function  $\kappa$  at drift wave velocity  $V_{De} =$  &  $T_{\perp}/T_{\parallel}=6$

Shows the relation between growth length  $(\gamma_L) R_E$  versus wave vector  $(K_{II}) \text{ cm}^{-1}$  for different values of kappa distribution function  $\kappa$  at drift wave velocity  $V_{De} =$  &  $T_{\perp}/T_{\parallel}=6$ . It is observed that the growth length  $(\gamma_L) R_E$  increases with increase in drift wave velocity  $V_{De}$ .

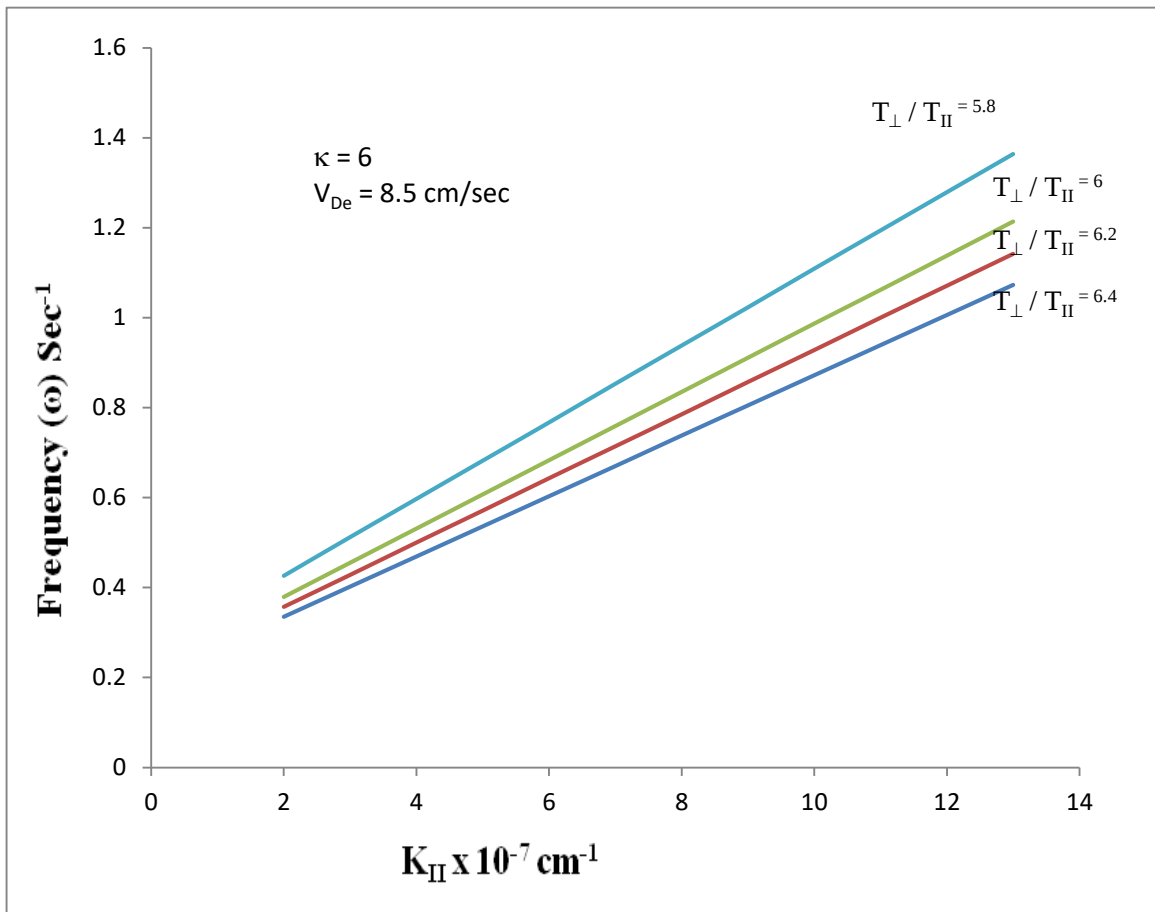


Fig. 2.4 The variation of real frequency ( $\omega$ )  $\text{sec}^{-1}$  versus wave vector ( $K_{II}$ )  $\text{cm}^{-1}$  for different values temperature anisotropy  $T_{\perp}/T_{\parallel}$  at drift velocity  $V_{De}=$  &  $\kappa=6$ .

Shows the relation between real frequency ( $\omega$ )  $\text{sec}^{-1}$  versus wave vector ( $K_{II}$ )  $\text{cm}^{-1}$  for different values temperature anisotropy  $T_{\perp}/T_{\parallel}$  at drift velocity  $V_{De}=$  &  $\kappa=6$ . It is observed that the real frequency ( $\omega$ ) enhanced the wave vector ( $K_{II}$ ). It is clear that the real frequency  $\omega$  increases with increases of wave vector ( $K_{II}$ )

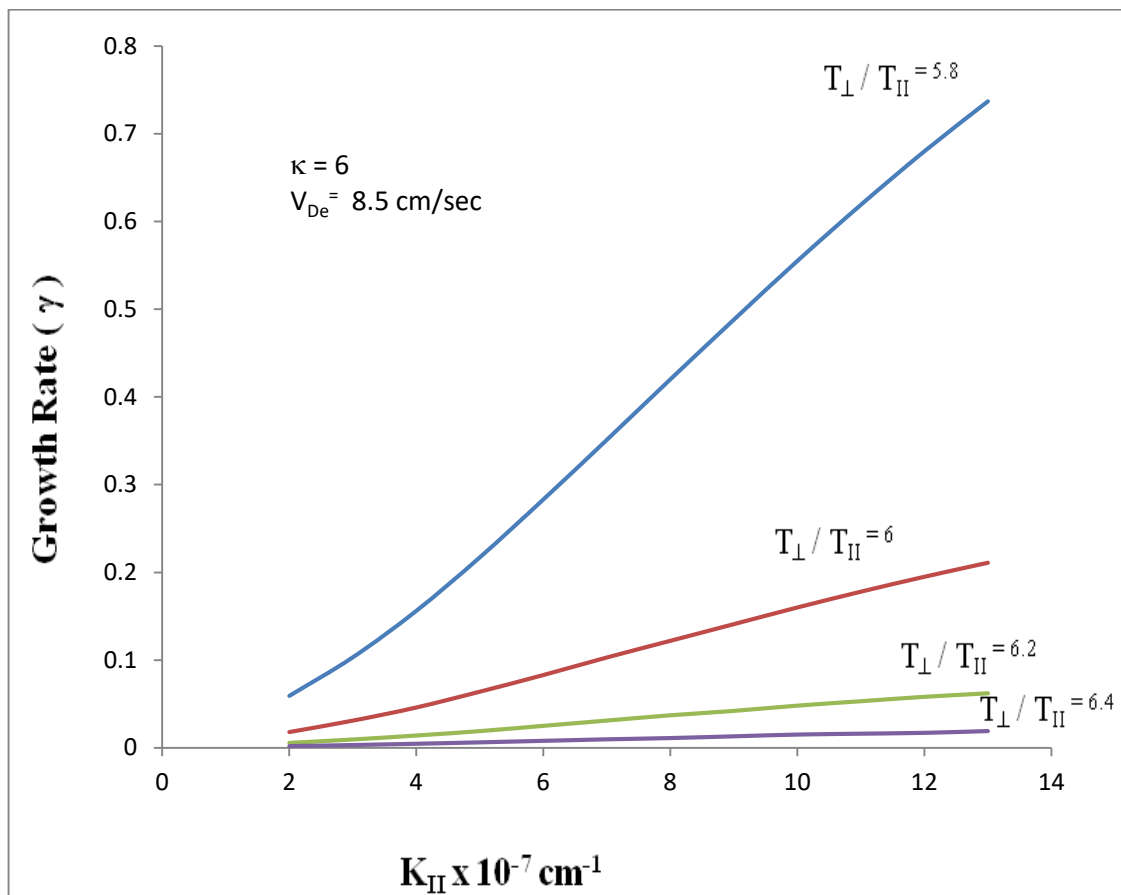


Fig. 2.5 The variation of growth/ damping rate ( $\gamma$ ) versus wave vector ( $K_{II}$ )  $\text{cm}^{-1}$  for different values of temperature anisotropy  $T_{\perp}/T_{\parallel}$  at drift velocity  $V_{De} = 8.5 \text{ cm/sec}$  &  $\kappa = 6$ .

The relation between of growth/ damping rate ( $\gamma$ ) versus wave vector ( $K_{II}$ )  $\text{cm}^{-1}$  for different values of temperature anisotropy  $T_{\perp}/T_{\parallel}$  at drift velocity  $V_{De} = 8.5 \text{ cm/sec}$  &  $\kappa = 6$ . It is observed that the growth rate ( $\gamma$ ) enhanced wave vector it's clear that the growth/ damping rate ( $\gamma$ ) increases with increase of wave vector ( $K_{II}$ ) the increase of damping rate ( $\gamma$ ) with increasing ( $K_{II}$ ).

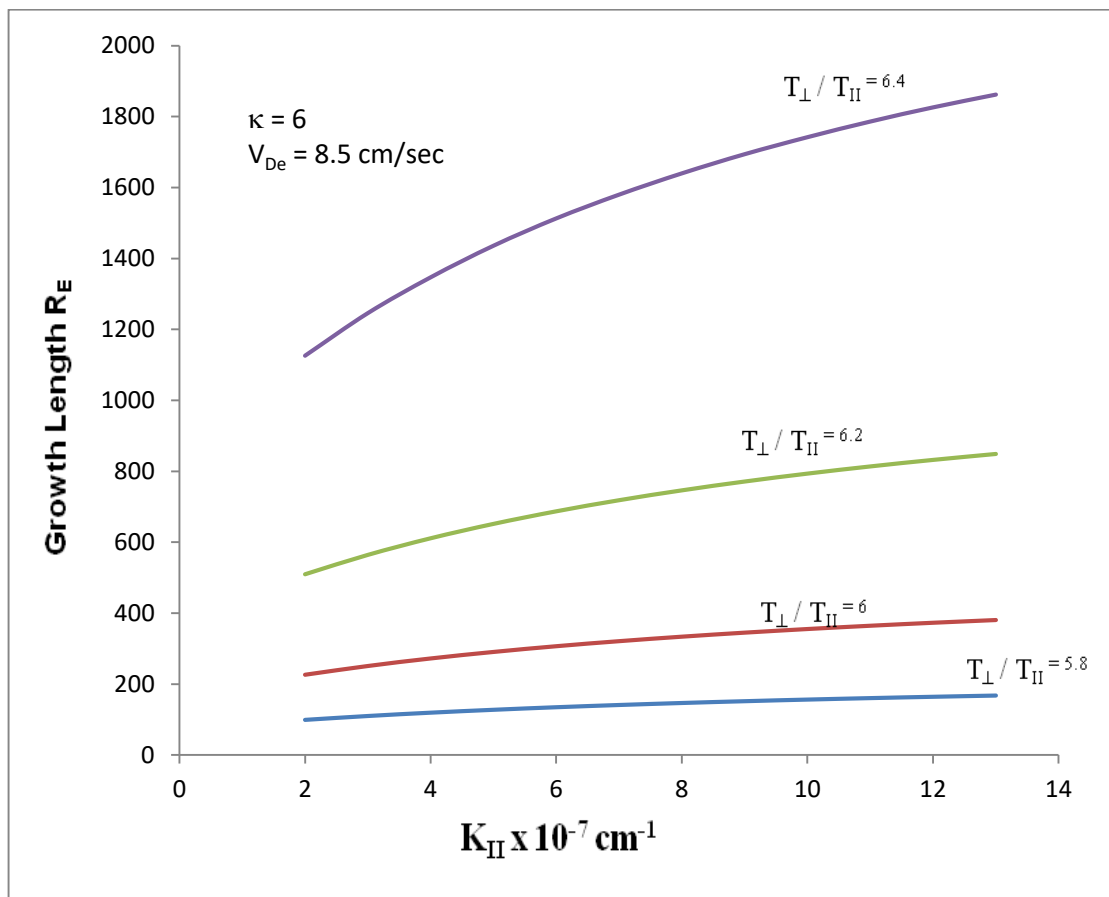


Fig. 2.6 The variation of growth length  $(\gamma_L) R_E$  versus wave vector  $(K_{II}) \text{ cm}^{-1}$  for different values of temperature anisotropy  $T_{\perp}/T_{\parallel}$  at drift velocity  $V_{De} = 8.5 \text{ cm/sec}$  &  $\kappa = 6$ .

Shows the relation between growth length  $(\gamma_L) R_E$  versus wave vector  $(K_{II}) \text{ cm}^{-1}$  for different values of temperature anisotropy  $T_{\perp}/T_{\parallel}$  at drift velocity  $V_{De} = 8.5 \text{ cm/sec}$  &  $\kappa = 6$ . It is observed that the growth length  $(\gamma_L) R_E$  increases with increase in wave vector  $(K_{II})$ .

### Summary:

In this present we've got delineated concerning Earth's region and magnetic flux, their formation and therefore they vary on top of the surface of earth and the density of atmosphere and their amendment with height from the surface of earth.

The particle aspects are used to gauge the expression of the dispersion relation, rate, and growth length for drift waves in the ionospheric region, and we are analyzing the results of alphabetic character distribution perform in conjunction with the temperature property of Kappa distribution function.

We have conferred the outlines of the study of the magnetic flux, the ionosphere, the drift behavior of waves, and the results of alphabetic character distributions, which tell us that the big and small perturbations on drift

and drift waves are close to the earth's plasma setting. During this chapter, we found that the process by which magnetic flux is made when the Earth's dipole is exposed to supersonic solar radiation is quite complex. This paper discusses the particle-side analysis of dif wave instability in magneto plasma, which is an extremely low plasma Although the rate of plasma particles follows alphabetic character distribution, we are able to grasp the alphabetic structure of particles For plasma dynamics and analysis of speed distribution perform, character perform is very important, which can be used to calculate the rate movements of the rate distribution perform through calculations This paper shows that our conclusion of the paper could be used to prove the dispersion properties of drift waves, as well as the mechanism of micro-instability of drift waves in a number of environments in which density irregularity and, therefore, temperature irregularity are not present. This work's primary application stems from drift wave acceleration of electrons within the auroral acceleration. We have talked about plasma instability with drift waves in this chapter. The free energy exists once the rate distribution of plasma particle isn't anisotropic once the plasma isn't uniform in house.

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