Comparative study between bi-Maxwellian & general distribution function on kinetic Alfven waves with multi-component plasma

R Tamrakar, P Varma and M S Tiwari

Department of Physics, Dr. H. S. Gour University, Sagar, M.P., India – 470003

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E-mail: radha.dhsgsu@gmail.com, poornimavarma@yahoo.com & tiwarims@yahoo.co.in

Corresponding email: radha.dhsgsu@gmail.com & poornimavarma@yahoo.com

Abstract. Kinetic Alfven waves in the presence of homogeneous magnetic field for bi-Maxwellian and loss cone distribution function with multi-component plasma are studied. The kinetic dispersion relation and growth/damping rate of kinetic Alfven wave (KAW) with multi-component plasma are derived theoretically by kinetic approach using Boltzmann-Vlasov equation for two distribution functions i.e., bi-Maxwellian and loss-cone distributions. The comparative study of both the distribution functions is investigated with multi-ions plasma (H^+, He^+ and O^+) using parameters of various space regions. Studies have shown that in real case both the distribution functions depart from the ideal case, so investigation of the comparison of deviation of growth/damping rate between bi-Maxwellian and loss-cone distribution function for different J values can be done with the derived equations and its effect on kinetic Alfven wave propagation can be analysed theoretically. The results of this study are assumed to be appropriate for various space regions.

Keywords. Kinetic Alfven waves, loss-cone distribution function, bi-Maxwellian distribution function, kinetic approach, auroral acceleration region, multi-component plasma.

38. Introduction

Alfven waves play an important role in many naturally occurring transient phenomena in space plasma. For the dispersive Alfven waves, perpendicular wavelength $k_\perp$ becomes comparable to the ion gyroradius ρ_i and the electron inertia length λ_e , such waves are known as kinetic Alfven waves. Kinetic Alfven waves are the low frequency electromagnetic waves propagating obliquely to the applied magnetic field.[1] Kinetic Alfven waves can possibly play an important role in the non-uniform fast heating of coronal loops in solar flares, energy transport, particle acceleration and heating, inducing field aligned currents and for cross energization of ions as well as for the field-aligned energization of electrons.[2],[3],[4] It was proposed that KAWs contribute in auroral plasma energization.[3][4]

The cluster observation on 18 march 2002 revealed small amplitude electromagnetic perturbation that were identified as drift Alfven waves with perpendicular wavelengths of order of the ion Larmor radius.[5],[6] Low frequency electromagnetic fluctuations observed in the auroral zone of the ionosphere and magnetosphere have been identified as KAWs. The Poynting flux occurring during high or moderately active times at highest latitude edge of auroral zone leads to strong earthward electron acceleration and precipitation.[1] Observational data from FAST and POLAR satellites have shown that these waves play an important role in particle acceleration in auroral acceleration region.[7]

In most of the theoretical work, the velocity distribution functions are assumed to be ideal Maxwellian but in most of the turbulent heating experiments non-Maxwellian distribution is allowed particularly loss cone distribution function.[8] A loss cone distribution is a distribution that has a deficiency of particles for small values of $v_\perp$ or small values of pitch angles α where $\alpha = \tan^{-1}\left(\frac{v_\perp}{v_\parallel}\right)$.[1],[9] In the Maxwellian isotropic velocity distribution function of ions the exchange of energy takes place from waves to the ions and the wave amplitude is attenuated. In the auroral region with curved and emerging magnetic field lines, distribution function departs considerably from the Maxwellian distribution and has steep loss cone distribution function which arises due to the plasma trapped in mirror configuration.[10]

In the past, Alfven waves and kinetic Alfven waves were analyzed using particle aspect approach and kinetic approach to study the dispersion relation, growth/damping rates, current and energy balance in homogenous plasma for two components (electron or proton only).[1],[5],[11],[12] But observational studies have indicated the presence of H^+, He^+ and O^+ ions in the auroral acceleration region.[13] The abundance of oxygen ions is observed to reach more than 30% or sometimes even as high as 80%, in the region where KAWs are identified.[14] It was reported that the energetic O^+ observed in KAW indicate that reconnection is a driver of auroral ion outflow [3] and by an appropriate choice of heavier ion densities and temperature, the dispersion characteristics of KAW can be made insensitive to the presence of these ions.[4]

This paper contains a mathematical derivation of the dispersion relation and the damping / growth rate of kinetic Alfven waves in the presence of bi-Maxwellian and general loss-cone distribution function through kinetic approach including the two regimes $k_\perp \rho_j < 1$ and $k_\perp \rho_j > 1$ for multi-ions plasma (H^+, He^+, O^+).

39. Basic trajectory

In this study it is considered that the plasma is immersed in a uniform, externally applied magnetic field B (along z-direction) and plasma is in equilibrium state characterized by charge neutrality $\sum_j n_j e_j = 0$ and zero external electric field E_0. Here, the collisionless Vlasov–Maxwell's equation [5, 15] is considered as,

$$\frac{\partial f_j(x,v,t)}{\partial t} + \mathbf{v} \bullet \nabla f_j(x,v,t) + \left[\frac{q_j[\mathbf{E}(x,t) + \mathbf{v} \times \mathbf{B}(x,t)]}{m_j}\right] \bullet \frac{\partial f_j(x,v,t)}{\partial \mathbf{v}} = 0 \tag{1}$$

where, $f_j(x,v,t)$ is unperturbed distribution function in six dimensional phase space, E(x,t)and B(x,t) are the electric and magnetic fields and q_j and m_j are the charge and mass of j particle component.
To determine the dispersion relation and growth/damping rate, bi-Maxwellian [5, 16] and general loss cone distribution functions [9, 17] are considered.

39.1. Bi-Maxwellian distribution is given as

$$F_j(\mathbf{v}_\perp, v_\parallel) = n_0 f_\perp(\mathbf{v}_\perp) f_\parallel(v_\parallel) \tag{2}$$

where, n_0 is zeroth order density and

$$f_j(\mathbf{v}_\perp) = \frac{1}{\pi v_{T\perp j}} \exp\left(-\frac{v_\perp^2}{v_{T\perp j}^2}\right) \tag{2a}$$

$$f_\parallel(v_\parallel) = \left(\frac{1}{\pi^{1/2} v_{T\parallel j}}\right) \exp\left(-\frac{v_\parallel^2}{v_{T\parallel j}^2}\right) \tag{2b}$$

where, $v_{T\perp j}^2 = 2T_{\perp j}/m_j$ and $v_{T\parallel j}^2 = 2T_{\parallel j}/m_j$ are the squares of perpendicular and parallel thermal velocity respectively, 39.2. Loss cone distribution function is given as

$$F_j(\mathbf{v}_\perp, v_\parallel) = n_0 f_\perp(\mathbf{v}_\perp) f_\parallel(v_\parallel) \tag{3}$$

where, n_0 is zeroth order density and

$$f_j(\mathbf{v}_\perp) = \frac{v_\perp^{2J}}{\pi v_{T\perp j}^{2(J+1)} J!} \exp\left(-\frac{v_\perp^2}{v_{T\perp j}^2}\right) \tag{3a}$$

$$f_\parallel(v_\parallel) = \left(\frac{1}{\pi^{1/2} v_{T\parallel j}}\right) \exp\left(-\frac{v_\parallel^2}{v_{T\parallel j}^2}\right) \tag{3b}$$

where, J is the loss cone index and is an integer which characterizes the steepness of loss cone, $v_{T\perp j}^2 = (J+1)^{-1} 2T_{\perp j}/m_j$ and $v_{T\parallel j}^2 = 2T_{\parallel j}/m_j$ are the squares of perpendicular and parallel thermal velocity respectively, $T_\perp$ and $T_\parallel$ are the temperature of charged particles perpendicular and parallel to the magnetic field (B), m_j is the mass of j component and $j \to electron\ , H^+, He^+, O^+$ for both the distributions.

40. General dispersion relation for kinetic Alfven waves

Considering plasma with an external magnetic field B in the z-direction and since the kinetic Alfven wave has its electric vector and wave vector in the same plane so it can be written [17,18]

$$\begin{vmatrix} D_{xx} & D_{xz} \\ D_{zx} & D_{zz} \end{vmatrix} = 0, \tag{4}$$

where,

$$D_{xx}(\mathbf{k},\omega) = 1 - \frac{c^2 k_z^2}{\omega^2} + \sum_j \frac{\omega_{pj}^2}{\omega} \sum_{n=-\infty}^{n=\infty} \int d^3v v_\perp \frac{\left(\frac{n}{b_j}\right)^2 J_n^2(b_j)}{(\omega - n\omega_{cj} - k_z v_z)} \times \left[\frac{\partial F_j}{\partial v_\perp} - \frac{k_z v_z}{\omega}\left(\frac{\partial F_j}{\partial v_\perp} - \frac{v_\perp}{v_z}\frac{\partial F_j}{\partial v_z}\right)\right] \tag{5}$$

$$D_{xz}(\mathbf{k},\omega) = \frac{c^2 k_z k_\perp}{\omega^2} + \sum_j \frac{\omega_{pj}^2}{\omega} \sum_{n=-\infty}^{n=\infty} \int d^3v v_\perp \frac{\left(\frac{n}{b_j}\right) J_n^2(b_j)}{(\omega - n\omega_{cj} - k_z v_z)} \times \left[\frac{\partial F_j}{\partial v_z} + \frac{n\omega_{cj}}{\omega}\left(\frac{v_z}{v_\perp}\frac{\partial F_j}{\partial v_\perp} - \frac{\partial F_j}{\partial v_z}\right)\right] \tag{6}$$

$$D_{zx}(\mathbf{k},\omega) = \frac{c^2 k_\perp k_z}{\omega^2} + \sum_j \frac{\omega_{pj}^2}{\omega} \sum_{n=-\infty}^{n=\infty} \int d^3v v_z \frac{\left(\frac{n}{b_j}\right) J_n^{\ 2}(b_j)}{(\omega - n\omega_{cj} - k_z v_z)} \times \left[\frac{\partial F_j}{\partial v_\perp} - \frac{k_z v_z}{\omega}\left(\frac{\partial F_j}{\partial v_\perp} - \frac{v_\perp}{v_z}\frac{\partial F_j}{\partial v_z}\right)\right] \tag{7}$$

$$D_{zz}(\mathbf{k},\omega) = 1 - \frac{c^2 k_\perp^2}{\omega^2} + \sum_j \frac{\omega_{pj}^2}{\omega} \sum_{n=-\infty}^{n=\infty} \int d^3v v_z \frac{J_n^2(b_j)}{(\omega - n\omega_{cj} - k_z v_z)} \times \left[\frac{\partial F_j}{\partial v_z} + \frac{n\omega_{cj}}{\omega}\left(\frac{v_z}{v_\perp}\frac{\partial F_j}{\partial v_\perp} - \frac{\partial F_j}{\partial v_z}\right)\right] \tag{8}$$

where, $\omega_{pj}^2 = \frac{4\pi n_j q_j^2}{m_j}$ is the square of plasma frequency, $\omega_{cj} = \frac{q_j B_0}{m_j c}$ is the cyclotron frequency, $b_j = \frac{k_\perp v_\perp}{\omega_{cj}}$, $\int d^3v = 2\pi \int_0^\infty \mathbf{v}_\perp d\mathbf{v}_\perp \int_{-\infty}^{+\infty} dv_\parallel$ and imaginary ω>0 is assumed.

Substituting the values of $\frac{dF_j}{dv_\perp}$ and $\frac{dF_j}{dv_\parallel}$ from equations (2a), (2b) and (3a), (3b) in equations from (5) to (8) and solving for two distribution functions, the dispersion tensor components are derived as:

40.1. Bi- Maxwellian distribution,

40.1.1. for $a_j < 1$,

$$D_{xx}(\mathbf{k},\omega) = 1 - \frac{c^2 k_\parallel^2}{\omega^2} + \frac{\omega_{pH^+}^2}{\omega_{cH^+}^2}\left(1 - \frac{3}{4}a_{H^+}\right) + \frac{\omega_{pHe^+}^2}{\omega_{cHe^+}^2}\left(1 - \frac{3}{4}a_{He^+}\right) + \frac{\omega_{pO^+}^2}{\omega_{cO^+}^2}\left(1 - \frac{3}{4}a_{O^+}\right) \tag{9}$$

40.1.2. for $a_j > 1$,

$$D_{xx}(\mathbf{k},\omega) = 1 - \frac{c^2 k_\parallel^2}{\omega^2} + \frac{\omega_{pH^+}^2}{\omega_{cH^+}^2}\frac{1}{a_{H^+}} + \frac{\omega_{pHe^+}^2}{\omega_{cHe^+}^2}\frac{1}{a_{He^+}} + \frac{\omega_{pO^+}^2}{\omega_{cO^+}^2}\frac{1}{a_{O^+}} \tag{10}$$

and;

$$D_{xz}(\mathbf{k},\omega) = D_{zx}(\mathbf{k},\omega) = \frac{c^2 k_\perp k_\parallel}{\omega^2} \tag{11}$$

$$D_{zz}(\mathbf{k},\omega) = 1 - \frac{c^2 k_\perp^2}{\omega^2} + 2\frac{1}{\delta}\frac{m_j}{m_e}\frac{\omega_{pj}^2}{k_\parallel^2 v_{T\parallel e}^2}\left[1 + i\sqrt{\frac{\pi}{2}}\frac{\omega}{k_\parallel v_{T\parallel e}}\sigma_e e^{-\xi_e^2}\right] \tag{12}$$

for both the regimes.

40.2. For loss-cone distribution function

$$D_{xx}(\mathbf{k},\omega) = 1 - \frac{c^2 k_\parallel^2}{\omega^2} - \frac{\omega_{pH^+}^2}{\omega_{cH^+}^2}\frac{D_1^J(\lambda_{H^+})}{\lambda_{H^+}} - \frac{\omega_{pHe^+}^2}{\omega_{cHe^+}^2}\frac{D_1^J(\lambda_{He^+})}{\lambda_{He^+}} - \frac{\omega_{pO^+}^2}{\omega_{cO^+}^2}\frac{D_1^J(\lambda_{O^+})}{\lambda_{O^+}} \tag{13}$$

$$D_{xz}(\mathbf{k},\omega) = D_{zx}(\mathbf{k},\omega) = \frac{c^2 k_\perp k_\parallel}{\omega^2} \tag{14}$$

$$D_{zz}(\mathbf{k},\omega) = 1 - \frac{c^2 k_\perp^2}{\omega^2} + \frac{1}{\delta}\frac{m_j}{m_e}\frac{\omega_{pj}^2}{k_\parallel^2 v_{T\parallel e}^2}C_0^J(\lambda_e)\left(1 + i\sigma_e\sqrt{\frac{\pi}{2}}\frac{\omega}{k_\parallel v_{T\parallel e}}e^{-\xi_e^2}\right) \tag{15}$$

where, $\sigma_e = \frac{k_\parallel}{|k|}$, $|k| = k_\perp^2 + k_\parallel^2$, $\xi_e = \frac{\omega}{\sqrt{2}k_\parallel v_{T\parallel e}}$, $a_j = \frac{1}{2}k_\perp^2\rho_j^2$, $\rho_j^2 = \frac{v_{T\perp j}^2}{\omega_{cj}^2}$ $\delta = \frac{n_j}{n_e}$, n_j and n_e is the density of ions and electrons respectively and

$$D_n^J(\lambda) = \int_0^\infty dv_\perp^2 \left(1 - \frac{Jv_{T\perp j}^2}{v_\perp^2}\right) J_n^2\left(\frac{k_\perp v_\perp}{\omega_{cj}}\right) \frac{v_\perp^{2J}}{v_{T\perp j}^2 .J!} \exp\left(-\frac{v_\perp^{2J}}{v_{T\perp j}^2}\right),$$

$$C_n^J(\lambda) = \int_0^\infty 2\pi v_\perp J_n^2\left(\frac{k_\perp v_\perp}{\omega_{cj}}\right) . \frac{v_\perp^{2J}}{\pi v_{T\perp j}^2 .J!} \exp\left(-\frac{v_\perp^{2J}}{v_{T\perp j}^2}\right),$$

$$Z(\xi_j) = \frac{1}{\sqrt{\pi}} \int_{-\infty}^{+\infty} \frac{\exp(-x^2)}{x - \xi_j} dx,$$

$$\omega_{pe}^2 = \frac{1}{\delta}\frac{m_j}{m_e}\omega_{pj}^2 \quad \xi_j = \frac{\omega - n\omega_{cj}}{k_\parallel v_{T\parallel j}}$$

(16)

$\lambda_j = \frac{1}{2}(J+1)a_j$ are used.

$$Z(\xi_j) \approx -\frac{1}{\xi_j} - \frac{1}{2\xi_j^3}, \text{ for ions} \qquad (17)$$

$$Z(\xi_e) \approx -2\xi_e + \frac{4}{3}\xi_e^2 + ... + \sigma_e i\sqrt{\pi}e^{-\xi_e^2}, \text{ for electrons} \qquad (18)$$

To derive the dispersion relation, the values of dispersion tensor are substituted in determinant (4) and are evaluated to obtain the dispersion relation as:

For bi-Maxwellian distribution, for $a_j < 1$ substituting values from (9), (11) and (12) in equation (4), the general dispersion relation is obtained as

$$\omega^2 = c^2 k_\parallel^2 \left[\frac{\omega_{cH^+}^2}{\omega_{pH^+}^2}\left\{1 + \left(\frac{3}{4} + \delta\frac{T_e}{T_{H^+}}\right)a_{H^+}\right\} + \frac{\omega_{cHe^+}^2}{\omega_{pHe^+}^2}\left\{1 + \left(\frac{3}{4} + \delta\frac{T_e}{T_{He^+}}\right)a_{He^+}\right\} + \frac{\omega_{cO^+}^2}{\omega_{pO^+}^2}\left\{1 + \left(\frac{3}{4} + \delta\frac{T_e}{T_{O^+}}\right)a_{O^+}\right\}\right] \qquad (19)$$

for $a_j > 1$ substituting values from (10), (11) and (12) in equation (4), the general dispersion relation is obtained as

$$\omega^2 = c^2 k_\parallel^2 \left[\frac{\omega_{cH^+}^2}{\omega_{pH^+}^2} a_{H^+}\left(1 + \delta\frac{T_e}{T_{H^+}}\right) + \frac{\omega_{cHe^+}^2}{\omega_{pHe^+}^2} a_{He^+}\left(1 + \delta\frac{T_e}{T_{He^+}}\right) + \frac{\omega_{cO^+}^2}{\omega_{pO^+}^2} a_{O^+}\left(1 + \delta\frac{T_e}{T_{O^+}}\right)\right] \qquad (20)$$

For loss-cone distribution function, values from (13), (14) and (15) are substituted in equation (4), and the general dispersion relation is obtained as

$$\omega^2 = c^2 k_\parallel^2 \left[\frac{\frac{\omega_{cH^+}^2}{\omega_{pH^+}^2}\frac{\lambda_{H^+}}{D_1^J(\lambda_{H^+})}}{\left(\delta_{H^+}\frac{T_e}{T_{H^+}}\frac{2\lambda_{H^+}}{C_0^J(\lambda_e)} - 1\right)} + \frac{\frac{\omega_{cHe^+}^2}{\omega_{pHe^+}^2}\frac{\lambda_{He^+}}{D_1^J(\lambda_{He^+})}}{\left(\delta_{He+}\frac{T_e}{T_{He^+}}\frac{2\lambda_{He^+}}{C_0^J(\lambda_e)} - 1\right)} + \frac{\frac{\omega_{cO^+}^2}{\omega_{pO^+}^2}\frac{\lambda_{O^+}}{D_1^J(\lambda_{O^+})}}{\left(\delta_{O+}\frac{T_e}{T_{O^+}}\frac{2\lambda_{O^+}}{C_0^J(\lambda_e)} - 1\right)}\right] \qquad (21)$$

Equations (18) and (19) gives the dispersion relation for bi-Maxwellian plasma consisting of multi-ions, these equations are similar to equation as obtained earlier [19, 20] and equation (21) is similar to equation obtained [17] if two component treatment is considered.

41. Growth/Damping Rate

It is assumed that the Im ω>1, so $\omega \rightarrow \omega_r + i\gamma$ with $\gamma << \omega$ and

$$\gamma = -\frac{\operatorname{Im} D(\mathbf{k},\omega)}{\left(\frac{\partial(\operatorname{Re} D(\mathbf{k},\omega))}{\partial \omega}\right)} \tag{22}$$

41.1. The growth/damping rate of bi-Maxwellian plasma is evaluated by substituting values of dispersio tensor in equation (22) and is obtained as

$$\gamma = -\sqrt{\frac{\pi}{8}} c^2 k_\perp^2 \left[\delta_{H^+}\frac{T_e}{T_{H^+}}\frac{1}{\omega_{pH^+}^2} + \delta_{He^+}\frac{T_e}{T_{He^+}}\frac{1}{\omega_{pHe^+}^2} + \delta_{O^+}\frac{T_e}{T_{O^+}}\frac{1}{\omega_{pO^+}^2}\right] k_\parallel v_{T\parallel e} \exp\left(-\xi_e^2\right) \tag{23}$$

The growth or damping rate for both the regimes i.e. $a_j < 1$ and $a_j > 1$ is equal.

41.2. For loss cone distribution, growth/damping is obtained as

$$\gamma = -\sqrt{\frac{\pi}{8}}\frac{c^2}{2} C_0^J(\lambda_e) e^{-\xi_e^2}\frac{1}{v_{T\parallel e}}\left[\begin{array}{l} \frac{1}{\delta_{H^+}}\frac{T_{H^+}}{T_e}\frac{\omega_{cH^+}^2}{\omega_{pH^+}^2}\frac{\lambda_{H^+}}{\left[D_1^J(\lambda_{H^+})\right]^2}\left\{\frac{1}{\left(\delta_{H^+}\frac{T_e}{T_{H^+}}\frac{2\lambda_{H^+}}{C_0^J(\lambda_e)}-1\right)}+1\right\}^2 \\ +\frac{1}{\delta_{He^+}}\frac{T_{He^+}}{T_e}\frac{\omega_{cHe^+}^2}{\omega_{pHe^+}^2}\frac{\lambda_{He^+}}{\left[D_1^J(\lambda_{He^+})\right]^2}\left\{\frac{1}{\left(\delta_{He^+}\frac{T_e}{T_{He^+}}\frac{2\lambda_{He^+}}{C_0^J(\lambda_e)}-1\right)}+1\right\}^2 \\ +\frac{1}{\delta_{O^+}}\frac{T_{O^+}}{T_e}\frac{\omega_{cO^+}^2}{\omega_{pO^+}^2}\frac{\lambda_{O^+}}{\left[D_1^J(\lambda_{O^+})\right]^2}\left\{\frac{1}{\left(\delta_{O^+}\frac{T_e}{T_{O^+}}\frac{2\lambda_{O^+}}{C_0^J(\lambda_e)}-1\right)}+1\right\}^2 \end{array}\right] \tag{24}$$

For steepness index J=0, 1, 2,... the general dispersion relation and damping/growth rate are evaluated b using the following identities and recurrence relations[18,21]

$$C_n^{J+1}(\lambda) = C_n^J(\lambda) + \frac{\lambda}{J+1}\frac{d}{d\lambda}C_n^J(\lambda) \tag{25}$$

$$D_n^{J+1}(\lambda) = \frac{J}{J+1}D_n^J(\lambda) + \frac{\lambda}{J+1}\frac{d}{d\lambda}D_n^J(\lambda) \tag{26}$$

$$\int_0^\infty dx^2 J_n^2(sx)\exp\left(-x^2\right) = \exp\left(-\frac{s^2}{2}\right) I_n(\lambda) \tag{27}$$

$$\int_0^\infty dx^2 x^2 J_n^2(sx)\exp\left(-x^2\right) = \exp\left(-\frac{s^2}{2}\right)\left[\frac{1}{2}s^2\left(I_n'(\lambda) - I_n(\lambda)\right) + I_n(\lambda)\right] \tag{28}$$

42. Result and discussion

Based on the multi-ion plasma, the dispersion relation and the growth/damping rate for the bi-Maxwellian and general loss cone plasma in two regimes i.e. $a_j < 1$ and $a_j > 1$ are presented. These equations show that the presence of heavy ions in space regions affects the dispersion and growth/ damping rate of KAW. The effects of temperature anisotropy due to multi-ions can also be studied for both the relations. As reported earlier, the damping of wave occurring due to wave particle interaction and Landau damping or the electromagnetic fluctuations in the auroral zone can be understood more clearly due to the effect of particular ion on the phenomena. The effect of variation of ion density on the wave can also be analyzed along with the increase in the steepness index and the effect of loss cone index on wave propagation affected by the presence of individual ion can also be approximated from present study. Hence, the comparative study of all the effects on the KAW can be done between the two distribution functions i.e. bi-Maxwellian and general distribution function.

43. Summary and conclusion

Present study can reveal the role of kinetic Alfven waves in heating the ambient medium, dissociation, ionization, and hence the acceleration and energization of plasma particles (H^+, He^+, O^+), leading to formation of aurora. The results may be helpful to understand the physical mechanism of energization processes for multi-ions in space plasma environment. The dispersion relation of loss cone distribution shows that distribution index affects the kinetic Alfven wave propagation in various space regions. It can also explain the various effects at the substorm times and may provide knowledge about the structure of space plasma environment, the facts that are still unknown. In conclusion, the results of present investigation will be useful in identifying the frequency and growth / damping rate of kinetic Alfven waves with two different distribution functions under variable effects with multi-ions.

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