Landau Damping for Electron waves in E Layer Ionosphere plasma in Mid latitude refer to Geomagnetic activity

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Abstract: The extracting Landau damping for electron waves in ionosphere E layer Mid latitude Plasma,theoretically discovered by Landau for non lossy medium in the case of non impacting particles that are an amazing achievements of plasma physics researches. This is in Turn an achievement in the field of applied mathematics .Then Landau damping is a characteristics of non impacting plasmas. In order to be familiar with the cause and effect of this process, we knew that the imaginary value of Im(ω) is a function of $V = V(\phi)$ that would be obtained from singularity Values of this factor and in other hand this originated from resonant particles of plasma. Surely the waves in Plasma move with phase velocity, then the Landau damping considered for electron Waves in the E layer, ionosphere Plasma medium in low latitude in the height about90-120km above the Earth surface. The time range considered Landau damping is the month June that the Plasma pronounced hardly and data selected from the ionospheric site Boulder Colorado (Boulder, Colorado, N 40^0 E 25.5^0). Our calculations showed that: Landau damping decreased for small values of $k\lambda_D$ while it increased for the small values of ω_{pe}. Pacs: 94.05.Lk, 94.20.Wf, 52.35.-g, 94.20.Fg, 94.20.We [M. Janserian, Z. Emami, A. Haghpeima, L. Ebrahimirazgale. **Landau Damping for Electron waves in E Layer Ionosphere plasma in Mid latitude refer to Geomagnetic activity**. *Life Sci J* 2013;10(1s):336-341] (ISSN:1097-8135). http://www.lifesciencesite.com. 54

Keywords: Landau Damping, Electron waves, E Layer ,Ionosphere plasma, Geomagnetic activity

Introduction

It is universally recognized that 99% of the known maters in the word are in the Plasma state . In completely ionized Plasma the frequency of the Plasma oscillation is electron Plasma [1]. Certainly the ionosphere Plasma is not fully ionized, then there would be the neutral particle in the Plasma in excess to electrons and ions [2].Landau damping is the characteristics of non impacting Plasma with both moving electrons faster and slower than the Plasma waves. If the electrons distribution function in the Plasma are Maxwellian then there are slower electrons in the Plasma more than faster ones. Then the interaction of the electrons- waves are so as that there are more receiving energy particles than submitting energy particles to the waves. This is why the waves damped in the Plasma media [3].

Material Method

Landau damping of the electron Plasma waves which for their process we used the Vlasov equation and the dispersion relation of the waves ,then for this first we used Boltzman equation as bellows: $\frac{\partial f}{\partial t} + V.\nabla f + \frac{F}{m}.\frac{\partial f}{\partial V} = \left(\frac{\partial f}{\partial t}\right)_c$

(1)

here $\frac{\partial f}{\partial t}$ means derivation refer to time[4] and

$$m\frac{dv}{dt} = F \qquad (2)$$

is the second law of Newton. Certainly in a sufficiently hot Plasma we disregard the particles impacts and the F is electromagnetic force (That is Lorentz force) .

Then the equation (1) will be:

$$\frac{\partial f}{\partial t} + V.\nabla f + \frac{q}{m}(E \times V \times B).\frac{\partial f}{\partial V} = 0 \qquad (3)$$

Which is the Vlasov equation and is the simple equation in Kinetic theory of the Plasma [5].we put the following :

$$D(p) = 1 + \chi_i + \chi_e = 0 \qquad (4)$$

And sellect the $\omega = ip$,so as :

$$\alpha_i = \frac{\omega_i}{k\upsilon_{T\sigma}}, \alpha = \frac{\omega}{k\upsilon_{T\sigma}}$$

In this formula it is assumed that:

$$|\alpha|\rangle\rangle 1$$

So the susceptibility of the waves would be [6]:

$$\chi_\sigma = \frac{1}{k^2\lambda_{D_\sigma}^2}\left\{1+\alpha\left[1-\frac{1}{\alpha}\left(1+\frac{1}{2\alpha^2}+\frac{3}{4\alpha^4}+\ldots\right)+i\pi^{1/2}\exp\left(-\alpha^2\right)\right]\right\}$$
$$=\frac{1}{k^2\lambda_{D_\sigma}^2}\left\{-\left(\frac{1}{2\alpha^2}+\frac{3}{4\alpha^4}+\ldots\right)+i\alpha\pi^{1/2}\exp\left(-\alpha^2\right)\right\}$$
$$=-\frac{\omega_{p^\sigma}^2}{\omega^2}\left(1+3\frac{k^2}{\omega^2}\frac{kT_\sigma}{m_\sigma}+\ldots\right)+i\frac{\omega}{k\upsilon T_\sigma}\frac{\pi^{1/2}}{k^2\lambda_{D_\sigma}^2}\exp\left(-\omega^2/k^2\upsilon_{T_\sigma}^2\right) \quad (5)$$

If we put $|\alpha|\rangle\rangle 1$ then for a pole the Equation will be:

$$D(p)=1+\chi_i+\chi_e=0$$
$$1-\frac{\omega_{p_e}^2}{\omega^2}\left(1+3\frac{k^2}{\omega^2}\frac{kT_e}{m_e}+\ldots\right)+i\frac{\omega}{k\upsilon T_e}\frac{\pi^{1/2}}{k^2\lambda_{D_\sigma}^2}\exp\left(-\omega^2/k^2\upsilon_{T_e}^2\right)$$
$$-\frac{\omega_{p_i}^2}{\omega^2}\left(1+3\frac{k^2}{\omega^2}\frac{kT_i}{m_i}+\ldots\right)+i\frac{\omega}{k\upsilon T_i}\frac{\pi^{1/2}}{k^2\lambda_{D_\sigma}^2}\exp\left(-\omega^2/k^2\upsilon_{T_i}^2\right)=0 \quad (6)$$

This relationship is similar to the Hydrodynamic dispersion relation obtained as following :

$$\omega^2=\omega_{pe}^2+3k^2\frac{kT_{e0}}{m_e} \quad (7)$$

Damped oscillations are function of Im(ω_i). But in this equation there is not imaginary term as in (6)

$$\frac{\omega_{pe}^2}{\omega_{pi}^2}=\frac{m_i}{m_e}$$

Generally speaking by this we mean that :

$$\upsilon_{Ti} << \upsilon_{Te}$$

And apart from ions, we reach to the following :

$$1-\frac{\omega_{pe}^2}{\omega^2}\left(1+3\frac{k^2}{\omega^2}\frac{kT_e}{m_e}+\ldots\right)+i\frac{\omega}{k\upsilon T_e}\frac{\pi^{1/2}}{k^2\lambda_{De}^2}\exp\left(-\omega^2/k^2\upsilon_{Te}^2\right)=0 \quad (8)$$

If we remember that $\omega = ip$ and $\omega=\omega_r+i\omega_i$

Then from this we put into (8), which after manipulation and rewriting (8) in the following form:

$$D\left(\omega_r+\omega_i\right)=D_r\left(\omega_r+i\omega_i\right)+iD\left(\omega_r+i\omega_i\right)=0 \quad (9)$$

We reached to the following:

$$D_r=1-\frac{\omega_{p_e}^2}{\omega^2}\left(1+3\frac{k^2}{\omega^2}\frac{kT_e}{m_e}+\ldots\right),\ D_i=\frac{\omega}{k\upsilon T_e}\frac{\pi^{1/2}}{k^2\lambda_{D_e}^2}\exp\left(-\omega^2/k^2\upsilon_{T_e}^2\right) \quad (10)$$

Because for damped oscillation that is :

$$\omega_i << \omega_r$$

And using Tylor expansion of (9) we reached to:

$$D_r(\omega_r)+i\omega_i\left(\frac{dD_r}{d\omega}\right)_{\omega=\omega_r}+i\left[D_i(\omega_r)+i\omega_i\left(\frac{dD_i}{d\omega}\right)_{\omega=\omega_r}\right]=0 \quad (11)$$

Now if we used $\omega_i << \omega_r$ then we will get :

$$D_r(\omega_r)\cong 0 \quad (12)$$

From which the damping frequency ω_i would be:

$$\omega_i=\frac{D_i(\omega_r)}{\frac{dD_r}{d\omega}} \quad (13)$$

And then:

$$\omega_r^2=\omega_{p_e}^2\left(1+3\frac{k^2}{\omega_r^2}\frac{kT_e}{m_e}\right)\cong\omega_{p_e}^2\left(1+3k^2\lambda_{D_e}^2\right) \quad (14)$$

The imaginary part of the frequency that is (13) and (10) called Landau damping or:

$$\omega_i=-\sqrt{\frac{\pi}{8}}\frac{\omega_{p_e}}{k^3\lambda_{D_e}^3}\exp\left(-\omega^2/k^2\upsilon_{T\sigma}^2\right)$$
$$=-\sqrt{\frac{\pi}{8}}\frac{\omega_{p_e}}{k^3\lambda_{D_e}^3}\exp\left[-\left(1+3k^2\lambda_{D_e}^2\right)/2k^2\lambda_{D_e}^2\right] \quad (15)$$

In equation (15) $\omega_i\langle 0$ is the damping factor [7].

Mathematical Calculation

The most important frequency feature of E layer ionosphere Plasma is its diurnal variation with its hardly occurrence in the summer time in the month June 2011 that obtained from ionospheric Bolder Colorado site , that refer to formula (15) the ω_i is the Landau damping factor calculated for the local time [8].Then, $\omega_i, \nu_s, k\lambda_D$ for the 06:00LT – 20:00LT in the month June are drawn.The K factor is used as the geomagnetic activity for this same duration Local time. in this research the electron temperature and density are obtained from table of site mentioned above [9] .Deby length for the electrons calculated from the following [10] :

$$\lambda_{De} = \left(\frac{\varepsilon_0 KT_e}{ne^2} \right)^{\frac{1}{2}} \qquad (16)$$

As a factor for this Plasma variation we used critical frequency of this Plasma foE , for the other parameter representing this Plasma occurrence we used Geomagnetic activity introduced with K factor and the electron cyclotron Plasma frequency as $\omega_{p_e} = \frac{qB}{m}$ also calculated , with these all mentioned above value through a computerized Program we obtained ω_i as Landau damping factor representing the ω_i hourly values of the E layer Plasma .So as a factor for Landau damping ωi $\nu_s, k\lambda_D$. are drawn in Figs-1 to -15.

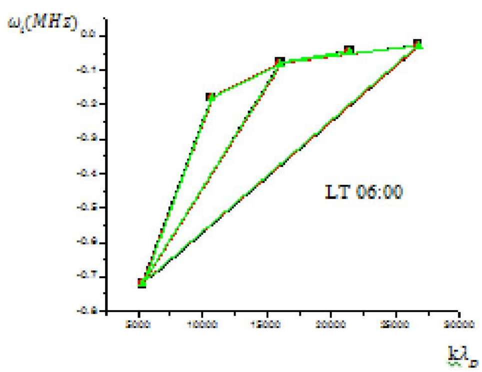

Fig-1.The Imaginary frequency ω_i (MHz) , ν_s, $k\lambda_D$, factor in 06:00 LT in the month June .

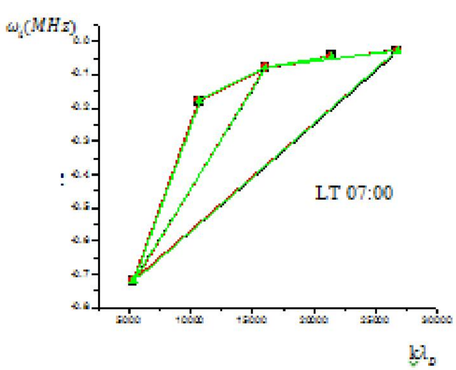

Fig-2.The Imaginary frequency ω_i (MHz) , ν_s, $k\lambda_D$, factor in 07:00 LT in the month June .

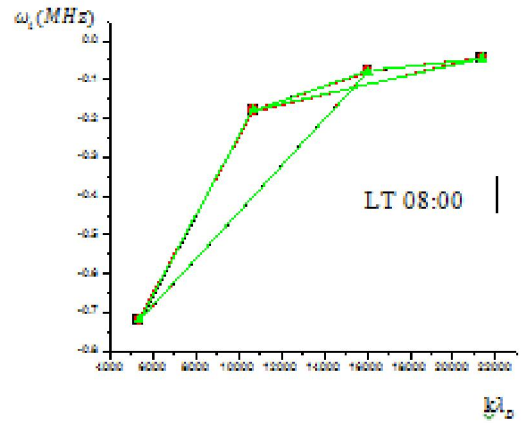

Fig-3.The Imaginary frequency ω_i (MHz) , ν_s, $k\lambda_D$, factor in 08:00 LT in the month June .

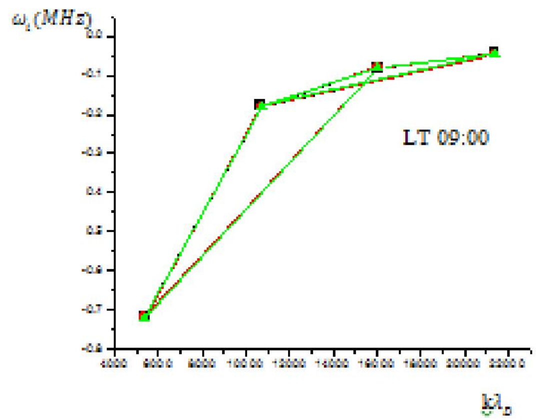

Fig-4.The Imaginary frequency ω_i (MHz) , ν_s, $k\lambda_D$, factor in 09:00 LT in the month June .

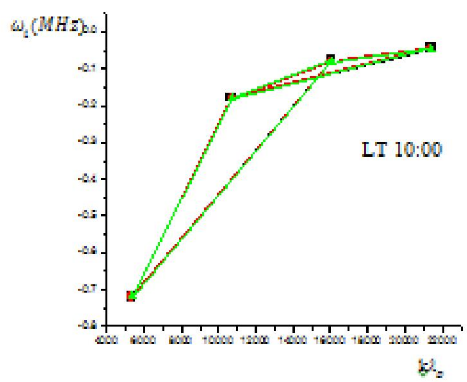

Fig-5.The Imaginary frequency ω_i (MHz) , ν_s, $k\lambda_D$, factor in 10:00 LT in the month June .

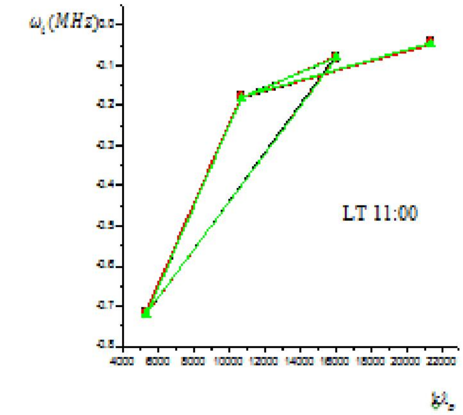

Fig-6.The Imaginary frequency ω_i (MHz), v_s, $k\lambda_D$, factor in 11:00 LT in the month June .

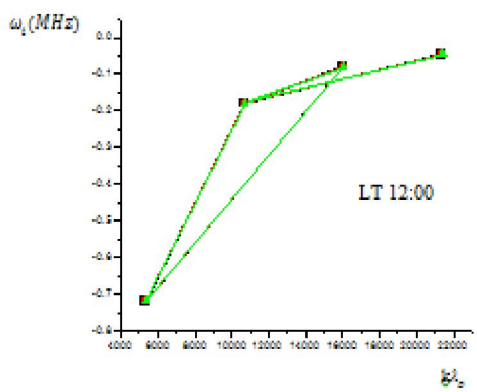

Fig-7.The Imaginary frequency ω_i (MHz), v_s, $k\lambda_D$, factor in 12:00 LT in the month June .

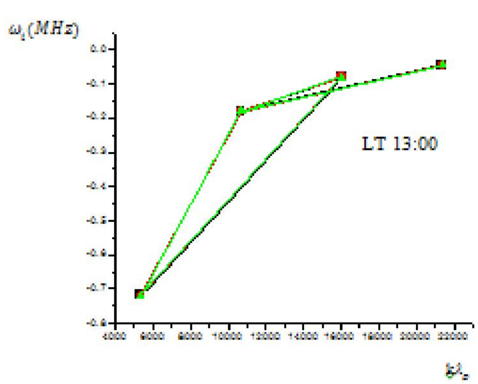

Fig-8.The Imaginary frequency ω_i (MHz), v_s, $k\lambda_D$, factor in 13:00 LT in the month June .

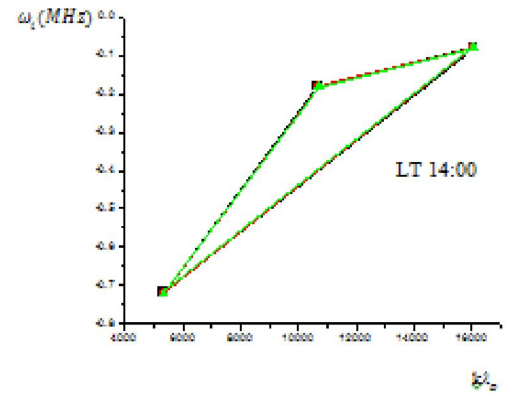

Fig-9.The Imaginary frequency ω_i (MHz), v_s, $k\lambda_D$, factor in 14:00 LT in the month June .

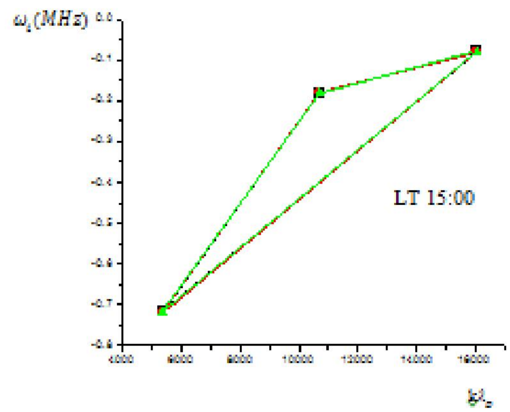

Fig-10.The Imaginary frequency ω_i (MHz), v_s, $k\lambda_D$, factor in 15:00 LT in the month June .

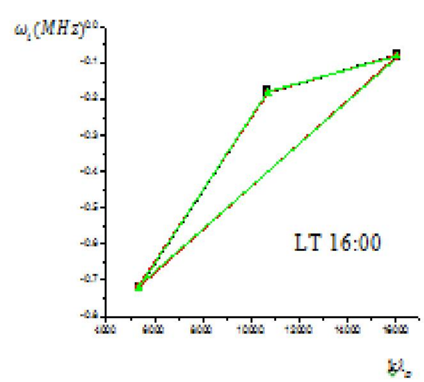

Fig-11.The Imaginary frequency ω_i (MHz), v_s, $k\lambda_D$, factor in 16:00 LT in the month June .

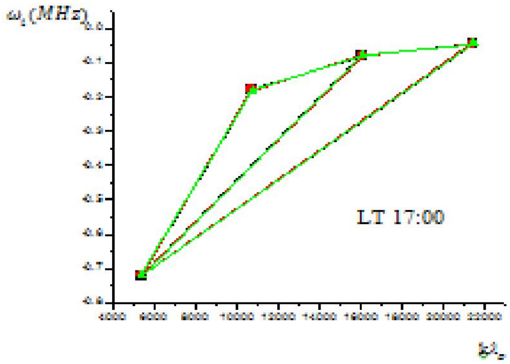

Fig-12.The Imaginary frequency ω_i (MHz) , V_s, $k\lambda_D$, factor in 17:00 LT in the month June .

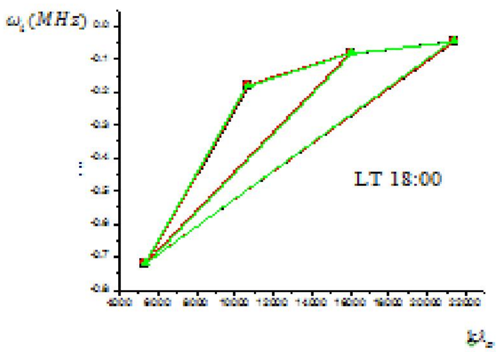

Fig-13.The Imaginary frequency ω_i (MHz) , V_s, $k\lambda_D$, factor in 18:00 LT in the month June .

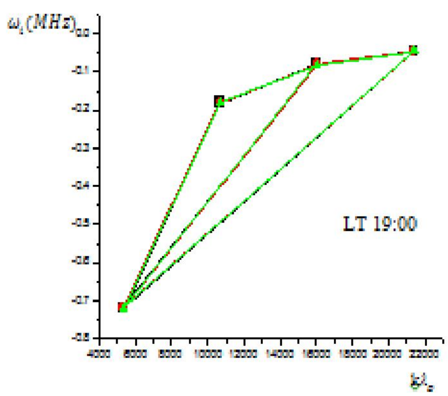

Fig-14.The Imaginary frequency ω_i (MHz) , V_s, $k\lambda_D$, factor in 19:00 LT in the month June .

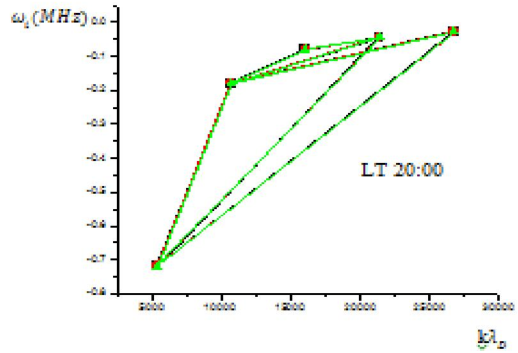

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Fig-15.The Imaginary frequency ω_i (MHz) , V_s, $k\lambda_D$, factor in 20:00 LT in the month June .

Conclusion Remarks

In this Resarch it is shown that :

1-Landau damping depends on the $\omega_{pe}, \lambda_{De}, K$, respectively

2-for low $k\lambda_{De}$ values , the Landau damping decreased and Vice Versa, with increasing $k\lambda_{De}$ Landau damping increased

3-The Landau damping depend inversely to the ω_{pe}

4-From 08:00LT to 13:00LT Landau damping decreased to the lower values of Landau damping is about 16:00LT

5-Landau damping again increased from 17:00LT to 19:00LT

6-The least damping values is in 17:00LT while its higheet values will be about 20:00LT

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