Depression and Excitation of Buneman's Instability in Two Ions Species Magnetized Dusty Plasma

Haifa Alyoussef (✉ umassema@post.com)

Princess Nourah bint Abdulrahman University

Research Article

Keywords: Dusty plasma, Multi ions plasma, an isotropic and non-isothermal plasma, Buneman's instability

Posted Date: December 4th, 2020

DOI: <https://doi.org/10.21203/rs.3.rs-115145/v1>

License: This work is licensed under a Creative Commons Attribution 4.0 International License.

[Read Full License](#)

Depression and Excitation of Buneman's Instability in Two Ions Species Magnetized Dusty Plasma

Haifa A. Al-Yousef

Physics Department, Faculty of Science, Princess Nourah Bint Abdulrahman University, Riyadh, Saudi Arabia

umassem@post.com

Abstract

In this research, theoretical method was used to examine the excitation and depression state for two-stream Buneman's instability (BI) when we assumed an inhomogeneous, anisotropic, multi ions species with the presence of dust grains in plasma. The plasma also studied at different temperatures state. The diffusion equation was also derived and solved in one dimension for the Buneman's instabilities that arise in such a situation within plasma. We develop the single-ion theory into a multiple-ion-species theory. This study concluded that: degree of plasma inhomogeneity, electron to ions temperature ratio, multi ions species and dust grains which have thermal velocity play a very important role in the depression and excitation of instability such Buneman's instability.

Keywords: Dusty plasma, Multi ions plasma, an isotropic and non-isothermal plasma, Buneman's instability.

Introduction

The relative motion of ions, electrons and dust grains, causes a current velocities $\vec{u} = \vec{u}_e - \vec{u}_{i(1,2),d}$, This takes place when using strong electric fields in devices contain plasma which has different types of ions (experimentally) [1] (e.g., at heating the plasma in closed magnetic traps and the discharges, for plasma turbulent heating, for Inducing electric fields in plasmas and for acceleration of plasmoids). If u is close to the value of the thermal velocity of the electrons $V_{Te} \approx u_e$ ($V_{Te} = \sqrt{\frac{T_e}{m_e}}$), then current instabilities are arised.

One of the most common current instabilities in the plasma is the two-stream Buneman's instability (BI) [1, 2]. It explains the stimulated Cerenkov radiation of low frequency, which appear in a current driven way where ion and electron drift as a beam at several velocities. This growing method causes creating very

strong local electric field, so the resulting scattered electrons leads to reinforced intense resistivity and heating for electron [1-3].

Some research assumes that the electrons move in the direction of a regular magnetic field so that their speed is equal to the thermal velocity of the electrons, ($u_e = V_{Te}$). Actually, numerical studies have been conducted for such instability by using very strong currents, as we consider the primary drift velocity of the electrons to be greater than the thermal velocity of the electrons, ($u_e > V_{Te}$).

The experimental results showed that there was an explosion of waves at Ultra High Frequency(UHF) (>250MHz) , which led to the emergence of the instabilities such as Buneman's instability at the beginning of the electric discharge of the plasma at high currents [9]. The Buneman's instability appear in unmagnetized and magnetized plasmas near the electron plasma frequency (in the electron framework reference), also the instability excited when the drift velocity of electron exceeds the thermal velocity of electron V_{Te} [4-6].

In the works cited above the plasmas were considered simply of two components, electron- one type of ions plasma. For a plasma, which contains multi ions species, Buneman's instability is of interest to both space and laboratory plasma physics because most real plasmas always have concentration ions, which may be due to impurities, or multi species ions etc. The importance of considering multi species ions lies in the fact that it could provide new information about the mechanism of acceleration via the dependence of energy on the charge to mass ratio. Multi-ion species plasma has also used to study Buneman's instability. [5-7].

However Multi-ion-species are strongly affected the low-frequency electromagnetic variations and energy relocated in plasma [8].

The two ion species in plasma system has been used experimentally to found Bohm criterion by using laser-induced fluorescence [9].

The turbulent transport of magnetic confinement plasmas including multi-ion-particle-species in helical systems showed that: while the heat transport of each particle species has slightly different sensitivity towards the plasma temperature gradients and the density gradients, there exist quite different dependencies in the particle transport on the radial gradient profiles of the plasma temperatures and densities between each particle species. [10]

Buneman's instabilities that formed in the plasma, which contains hydrogen ions (H), helium ions (He), and electrons prove that the waves increase in the beginning and create electric field bigger than the temperature of electron. This field confines little of electrons and leads to saturation for Buneman's waves, also that field reflects some of H ions and causes acceleration for them, while it does not effect on helium He ions which have a less value of thermal velocity [11].

That study found, in the second case, that electric field which produce Buneman's waves to become very much bigger than the electron temperature and highly effect on energy transport. This field confine some electrons, the field, $f_e(V_{||})$ is disfigured and expand much more than in smaller current case. Also, the field reflects some H ions, this causes increasing the parallel part of kinetic energy $k_{||}$ more than the perpendicular part of energy $k_{\perp}$; in the smaller current case, the growing of $k_{||}$ was very small.

In spite of He ions that have a smaller thermal velocity are not reflected by the field, they are warmed up by H cyclotron waves unstable by the change in $f_e(V_{||})$. So, H cyclotron waves and the instabilities of the Buneman's waves, $f_e(V_{||})$ has a flat surface much larger than the first value of thermal velocity as a result.

Current-driven instabilities (e.g., Buneman and ion-acoustic instabilities) and transfer of energy in a multi-ion-species plasma are significant problems in the acceleration and heating of ions in laboratory and space plasmas [12, 13].

In this work, we expand the single-ion theory by developing a multi-ion-species method. We investigate Buneman's instability in dusty plasma with two types of ions, considering various temperature ratios of electrons, ions and dusts. The mechanism of damping or growing for such instability is also studied in detail.

1. Kinetic Dispersion Relation

By considering an inhomogeneous plasma immersed in a static magnetic field $\vec{H}_0 = \vec{e}_z H_0$, at low temperature, magnetized in weakly form, with two types of ions and dusts in plasma. Also, we suppose inhomogeneity of density in plasma is in perpendicular direction to $\vec{H}_0$, i.e., in z-axis direction.

In dusty plasma case with two types of ions, the quasi-neutrality condition should be corresponded to as:

$$\sum_{\alpha}^{e,i(1,2),d} e_{\alpha} n_{\alpha 0} = 0$$

And if β is low (β the ratio of thermal pressure to magnetic pressure), the Kinetic dispersion equation in kinetic theory, which describes the system, is given by:

$$\varepsilon(\vec{k}, \omega) = 1 + \sum_{\alpha}^{e, i(1,2), d} \chi_{\alpha} = 0 \quad (1)$$

Where, $\chi_{\alpha} = \frac{\omega_{p\alpha}^2}{k_{\parallel}^2 V_{T\alpha}^2} \left[1 + i\sqrt{\pi} \hat{l}_{\alpha} Z_{\alpha} W(Z_{\alpha}) A(\mu_{\alpha}) \right]$ is the plasma susceptibilities, $k_{\parallel}$ represent the

wave number which be in parallel direction of the $\vec{H}_0$, α denote to type of particles, i.e., for electrons.

Ions and dust respectively ($\alpha = e, i(1,2), d$). The operator $\hat{l}_{\alpha}$ describe the effect of inhomogeneity in

density and temperature in plasma, $\hat{l}_{\alpha} = 1 - \frac{k_y V_{T\alpha}^2}{(\omega - \vec{k} \vec{u}_{\alpha}) \omega_{c\alpha}} \left[\frac{\partial}{\partial x} \ln n_{\alpha} + \frac{\partial}{\partial x} \ln T_{\alpha} \right]$ and we will consider in

this study only the inhomogeneity in density, i.e., $(\frac{\partial}{\partial x} \ln T_{\alpha} = 0)$. $A(\mu_{\alpha})$ this quantity represents the

magnetic field effect, $A(\mu_{\alpha}) = I_0(\mu_{\alpha}) e^{-\mu_{\alpha}}$, $\mu_{\alpha} = k_{\perp}^2 \rho_{\alpha}^2$, $k_{\perp}$ is wave number which

represent perpendicular component to $\vec{H}_0$, $\rho_{\alpha} = \frac{V_{T\alpha}}{\omega_{c\alpha}}$ is Larmor radius, $\omega_{c\alpha} = \frac{e_{\alpha} H_0}{m_{\alpha} c}$ is the

cyclotron frequency, $V_{T\alpha} = \sqrt{\frac{T_{\alpha}}{m_{\alpha}}}$ give the thermal velocity, $I_0(\mu_{\alpha})$ is the modified Bessel function

of zero order, and $\omega_{p\alpha} = \sqrt{\frac{4\pi e^2 n_{\alpha}(x)}{m_{\alpha}}}$ the Langmuir frequency $W(Z_{\alpha})$ represent the probability integral

that have amplitude $Z_{\alpha} = \frac{\omega - \vec{k} \vec{u}_{\alpha}}{\sqrt{2} k_{\parallel} V_{T\alpha}}$.

If heavy particles have the same velocity, i.e., $\vec{k} \vec{u}_{i(1,2)} \approx \vec{k} \vec{u}_d$ and setting

$\omega' = \omega - \vec{k} \vec{u}_d = \omega - \vec{k} \vec{u}_{i(1,2)}$ then Z_{α} for other type particle are:

$$Z_e = \frac{\omega' - \vec{k}\vec{u}}{\sqrt{2}k_{\parallel}V_{re}}, \quad Z_{(i(1,2),d)} \cong \frac{\omega'}{\sqrt{2}k_{\parallel}V_{T(i(1,2),d)}}$$

Where, $\vec{k}\vec{u} = ku\cos\theta$ (θ is the angle between $\vec{k}$ and $\vec{u} = \vec{u}_e - \vec{u}_{i(1,2)}$). For simplicity, we consider both ions $\vec{u}_{i(1)}$ and $\vec{u}_{i(2)}$ are parallel. Also, let us consider a dusty plasma with **low** massive ions compared to dusts, i.e. $\frac{m_d}{m_{i(1,2)}} \gg 1$.

2. Instability Thresholds

For excitation of instability we consider a small perturbation for the physical quantities as follows:

$u \rightarrow u_{cr} + \Delta u$, $\omega' \rightarrow \omega_0 + \Delta\omega$, with $\Delta\omega = \omega_k + i\gamma_k$, where γ_k and ω_k indicate the growth rate and frequency for the instability, respectively and ω_0 , u_{cr} are the critical values for frequency and current velocity. As well, we consider $Z_{\alpha} = Z_{0\alpha} + \Delta Z_{\alpha}$. For such small perturbations, we have $(\frac{\Delta u}{u_{cr}}, \frac{\Delta\omega}{\omega}, \frac{\Delta k}{k}, \theta) \ll 1$.

Now, if we have very weak magnetization for dust particle, $\mu_d \ll 1$ and within the frequency range specified in condition $|\vec{k}\vec{u}_{i(1,2)}, \vec{k}\vec{u}_d| \ll \omega'$, $|\omega_{ne}| \ll |\omega' - \vec{k}\vec{u}|$, and $|\vec{k}\vec{u}| < \omega'$ then we can apply the following relations:

$$Z_{0[i(1,2)]} \approx Z_{0d} \gg Z_{0e}; Z_{0d} > 1; Z_{0e} \ll 1; Z_{0e} = \frac{\omega_0 - ku_{cr}}{\sqrt{2}k_{\parallel}V_{Te}}; Z_{0[i(1,2),d]} = \frac{\omega_0}{\sqrt{2}k_{\parallel}V_{T[i(1,2),d]}};$$

$$A(\mu_{i(1,2)}) = \frac{1}{\sqrt{2\pi\mu_{i(1,2)}}}; A(\mu_d) = 1; A(\mu_e) = 1 - \mu_e; \hat{l}_{e,d} \approx 1, \hat{l}_i \approx 1 - \frac{\omega_{ni(1,2)}}{\omega_0}, \text{ where,}$$

$$\omega_{n\alpha} = \frac{k_{\parallel}V_{T\alpha}^2}{\omega_{c\alpha}} \chi_{n\alpha}, \quad \chi_{n\alpha} = \frac{\partial \ln n_{0\alpha}}{\partial x};$$

Under the conditions of weak density inhomogeneity of electrons compared to that of ions, i.e.,

$$\frac{\omega_{ne}}{\omega_{n[i(1,2)]}} = \left(\frac{T_e}{T_{i(1,2)}} \right) \left(\frac{n_{0[i(1,2)]}}{n_{0e}} \right) \left(\frac{\partial n_{0e} / \partial x}{\partial n_{0[i(1,2)]} / \partial x} \right) \ll 1, \quad \omega_{n\alpha} = \frac{k_{\parallel} V_{T\alpha}^2}{\omega_{c\alpha}} \frac{\partial \ln n_{0\alpha}}{\partial x};$$

We also assume that the change in the density of the ions only (and the magnitude of the influence of the magnetic field) while neglecting the change in temperature $T_d / T_{i(1,2)}$, or dusty plasma, we have for the Larmor radii:

$$\frac{\rho_d}{\rho_{i(1,2)}} = \sqrt{\frac{T_d}{T_{i(1,2)}}} \sqrt{\frac{m_d}{m_{i(1,2)}}} \frac{e_{i(1,2)}}{e_d} \gg 1$$

Based on the above-mentioned considerations (which are consistent with the experimental results) [14], the dispersion relation (1) can be rewritten as follows:

$$1 + k^2 r_{de}^2 + i\sqrt{\pi}(1 - \mu_e)Z_e W(Z_e) + \frac{T_e}{T_{i(1,2)}} i\sqrt{\pi} \frac{1}{\sqrt{2\pi\mu_{i(1,2)}}} \left(1 - \frac{\omega_{n[i(1,2)]}}{\omega_0}\right) Z_{i(1,2)} W(Z_{i(1,2)}) + \frac{T_e}{T_d} \cdot \frac{n_d}{n_e} \left(1 + i\sqrt{\pi} Z_d W(Z_d)\right) = 0 \quad (2)$$

Where: $r_{de} = \frac{V_{Te}}{\omega_{pe}}$ is the Debye radius for electrons.

It is clear from (2) the strongly dependence of Buneman's Instability dispersion is on the types of ions, inhomogeneity, magnetization, and temperature ratios of particles.

Set into (2) ω' as pure quantity ($\omega' \rightarrow \omega_0$) and $u \rightarrow u_{cr}$, we obtain the critical value of velocity instability as:

$$u_{cr} = \sqrt{\frac{\pi}{8}} \frac{V_{Ti(1,2)}^2}{V_{Te}} \left(1 - \frac{\omega_{ni(1,2)}}{\omega_0}\right)^{-1} \frac{\omega_0}{\omega_{ci(1,2)}} \frac{T_{i(1,2)}}{T_e} \left[1 + \frac{T_e}{T_d} \frac{n_d}{n_e} \frac{V_{Te}}{V_{Td}}\right]^2 \quad (3)$$

For rarefied dusty plasma $\frac{n_d}{n_e} \ll 1$, and the fulfilment of condition $\frac{T_e}{T_d} \frac{n_d}{n_e} \frac{V_{Te}}{V_{Td}} \ll 1$, (3) reads:

$$u_{cr} = \sqrt{\frac{\pi}{8}} \frac{V_{Te}^2}{V_{Te}} \left(1 - \frac{\omega_{ni(1,2)}}{\omega_0}\right)^{-1} \frac{\omega_0}{\omega_{ci(1,2)}} \frac{T_{i(1,2)}}{T_e}, \quad (4)$$

Which shows that u_{cr} is absolutely independent on dust (completely independent of dust), and multi ion spices in plasma leads to delay appearance of Buneman instability.

For strongly dusty plasma $\frac{n_d}{n_e} \gg 1$, then u_{cr} reads:

$$u_{cr} \cong \sqrt{\frac{\pi}{8}} \frac{V_{Te}}{\omega_{c[i(1,2)]}} \left(\frac{V_{T[i(1,2)]}}{V_{Td}}\right)^2 \frac{T_{i(1,2)}}{T_e} \omega_0 \left(\frac{T_e}{T_d}\right)^2 \left(\frac{n_d}{n_e}\right)^2 \left(1 + \frac{\omega_{ni(1,2)}}{\omega_0}\right) \quad (5)$$

Let us denote for two ions species $(1,2) \rightarrow (two\ ion)$, and for one ion $(1) \rightarrow (one\ ion)$

We can conclude that: $u_{cr(one\ ion)} > u_{cr(two\ ion)}$

Where:

$$m_{(one-ion)} < m_{(two-ions)}, V_{T(one-ion)} > V_{T(two-ions)}, \text{ and } \omega_{c(one-ion)} > \omega_{c(two-ions)}$$

Which means that two ion species in dusty plasma leads to appearance of Buneman's instability faster than that of one type of ions [2].

We can study two cases of ion inhomogeneity: weak inhomogeneity of ions $\frac{\omega_{n[two-ions]}}{\omega_0} \ll 1$ and strong inhomogeneity of ions $\frac{\omega_{n(tow\ ion)}}{\omega_0} \gg 1$,

Accordingly, we get have:

$$(u_{cr(two-ions)})_{strong} \cong \frac{\omega_{ni[two-ions]}}{\omega_0} V_{cr}, \quad (u_{cr})_{weak} \cong V_{cr}$$

Where,

$$V_{cr} = \sqrt{\frac{\pi}{8}} \frac{V_{Te}}{\omega_{c[two-ions]}} \left(\frac{V_{Ti[two-ions]}}{V_{Td}}\right)^2 \frac{T_{[V]}}{T_e} \omega_0 \left(\frac{T_e}{T_d}\right)^2 \left(\frac{n_d}{n_e}\right)^2, \text{ and it is easily to conclude that:}$$

$$\frac{(u_{cr})_{strong}}{(u_{cr})_{weak}} \cong \frac{\omega_{n[two \cdot ions]}}{\omega_0} \gg 1 \quad (6)$$

This prove that Buneman instability appears faster way in case strong inhomogeneity of ion in plasma with two ions compared to that with weak inhomogeneity of ion.

For different temperature regimes, equation (3) reads:

$$u_{cr} = U_{cr} M_1, \quad M_1 = \left(\frac{T_{[two \cdot ions]}}{T_e} \right)^{3/2} \gg 1, \quad u_{cr} = U_{cr} M_2, \quad M_2 = \left(\frac{T_{[two \cdot ions]}}{T_e} \right)^{3/2} = 1$$

$$u_{cr} = U_{cr} M_3, \quad M_3 = \left(\frac{T_{[two \cdot ions]}}{T_e} \right)^{3/2} \ll 1, \quad (7)$$

Where,

$$U_{cr} = \sqrt{\frac{\pi}{8}} \sqrt{\frac{m_e}{m_{i[two \cdot ions]}}} \frac{\omega_0}{\omega_{ci[two \cdot ions]}} \left(1 + \frac{T_e n_d V_{Te}}{T_d n_e V_{Td}} \right)^2 \left(1 - \frac{\omega_{ni[two \cdot ions]}}{\omega_0} \right)^{-1} V_{Ti(two \cdot ions)}.$$

At $(T_{[two \cdot ions]} \gg T_e)$, Buneman's instabilities forms and causes high electrostatic potentials that trap some electrons and dust, so that they all move with the ions within these domains.[2, 5, 16, 17]

However, such instability appears very fast in hot electron plasma or isothermal than in hot ion plasma.

So, the threshold value of velocity in dusty two ion spices plasma satisfies the following inequality for different temperature cases:

$$u_{cr}(M_1 \gg 1) \gg u_{cr}(M_2 = 1) \gg u_{cr}(M_3 \ll 1) \quad (8)$$

I.e., When the temperature of the electrons increases in relation to the temperature of the ions, the Buneman's instabilities appear much faster. While the presence of multiple types of ions in the plasma leads to delaying the emergence of instabilities of Buneman in the plasma under the conditions specified above.

3. Excitation of Instability

Excitation of Buneman's instability causes a very strong perturbation situation in plasma. When the turbulence reaches a certain value, the plasma gets heated, which leads to a rapid increase in the critical value of the current velocity u_{cr} of instability. As a result, it will be very important to examine and analyze instabilities when their current velocity u reaches a critical value.

Consequently, it will be very large important to investigate in this work the instabilities at current speed approximately equal to the threshold values.

Furthermore, as normal [e.g., 1, 2], let us consider the current velocity is a little transcend to the instability critical value, i.e., we set $u = u_{cr} + \Delta u$, where, $\Delta u \ll u_{cr}$. We also consider a small turbulent in the wave numbers and frequencies (here, $\gamma_k, \omega_k \neq 0$).

After long calculations, but not complex, we obtain the next dispersion relation for Buneman's instability in dusty plasma with two ions species:

$$\begin{aligned} \frac{T_e}{T_{[two \cdot ions]}} \frac{1}{\sqrt{2\mu_{[two \cdot ions]}}} \frac{\omega_{n[two \cdot ions]}}{\omega_0^2} \Delta\omega \left(iZ_{0[two \cdot ions]} \bar{e}^{Z_{[two \cdot ions]}^2} - 1 \right) + \sqrt{\pi} (1 - \mu_e) \Re_{0e} \frac{\Delta\omega + ku_{cr} \frac{\theta^2}{2} - k\Delta u}{\sqrt{2kV_{Te}}} + \\ \frac{T_e}{T_{[two \cdot ions]}} \frac{1}{\sqrt{2\mu_{[two \cdot ions]}}} \left(1 - \frac{\omega_{n[two \cdot ions]}}{\omega_0} \right) \Re_{0[i(1,2)]} \frac{\Delta\omega}{\sqrt{2kV_{T[two \cdot ions]}}} + \sqrt{\pi} \frac{T_e}{T_d} \frac{n_d}{n_e} \Re_{0d} \frac{\Delta\omega}{\sqrt{2kV_{Td}}} = 0 \end{aligned} \quad (9)$$

Where, $\Re_{0\alpha} = ie^{-Z_{0\alpha}^2} (1 - 2Z_{0\alpha}^2) - \frac{1}{\sqrt{\pi}Z_{\alpha}}$, $\mu_{\alpha} = k_{\perp}^2 \rho_{\alpha}^2$.

The dispersion relation (9) gives the frequency (High frequency) and the growth rate of Buneman's instability in inhomogeneous, dust grain in plasma, with two type of ions for various temperature regimes as follows:

$$\gamma_k \cong M_n \cdot \sqrt{2\pi\mu_{[two \cdot ions]}} (1 - \mu_e) \left(\frac{\Delta u}{u_{cr}} - \frac{\theta^2}{2} \right) \frac{ku_{cr}}{1 + (\Re_1 + \Re_2)^2} (\Re_1 + \sqrt{\omega}\Re_2) \quad (10)$$

$$\omega_k \cong \sqrt{\pi}Z_{oe} \bar{e}^{Z_{oe}^2} (1 - 2Z_{oe}^2) \gamma_k \quad (11)$$

Where,

$$\Re_1 = \sqrt{\pi} Z_{0[two \cdot ions]} \bar{e}^{Z_{0[two \cdot ions]}^2} \left[1 - 2Z_{0[two \cdot ions]}^2 \left(1 - \frac{\omega_{n[two \cdot ions]}}{\omega_0} \right) \right], \quad \Re_1 \propto \sqrt{m_{[two \cdot ions]}}$$

$$\Re_2 = \frac{T_{[two \cdot ions]}}{T_e} \sqrt{2\pi\mu_{[two \cdot ions]}} \left\{ \frac{T_e}{T_d} \frac{n_d}{n_e} \sqrt{\pi} Z_{0d} \bar{e}^{Z_{0d}^2} \left[-(1 - 2Z_{0d}^2) \right] \right\}$$

Here, growth rate and frequency of Buneman's instability are strongly affected by masses of existence of two ions species (i.e., much growing of such instability).

From other point of view, M_n indicates the temperature ratio, i.e.

$$M_n = \frac{T_{[two \cdot ions]}}{T_e}, \quad n = 1, 2, 3, \quad M_1 \gg 1, \quad M_2 = 1, \quad M_3 \ll 1$$

Accordingly, we can conclude that:

$$\gamma_{k[two \cdot ion]} \ll \gamma_{k[two \cdot ions]} \\ \omega_{k[one \ ion]} \ll \omega_{k[two \cdot ions]}$$

This means that the multi ions species in isothermal or non-isothermal dusty plasma leads to sharp increasing for both the frequency and growth rate of Buneman's instability.

From (10), the conditions of instability are given by:

$$\mu_e < 1, \quad \sqrt{2 \frac{\Delta u}{u_{cr}}} > \theta, \quad Z_{0i} < \sqrt{\frac{1}{2}} \text{ (for } \frac{\omega_{n[two \cdot ions]}}{\omega_0} \ll 1), \quad (\Re_1 + \sqrt{\omega} \Re_2) > 0 \quad (12)$$

The value of the growth rate (10) of Buneman's instabilities in dusty plasmas with multiple ions achieves the following inequality for various temperature ratios states:

$$\gamma_k(M_1) \gg \gamma_k(M_2) \gg \gamma_k(M_3) \quad (13)$$

It is evident from the equation (13) that the gradual increase in the temperature of the electrons greater than the temperature of the ions leads to the decay of the instabilities of Buneman in the linear phase. Also, the presence of dust particles affects the instability states, as it evident from the following condition:

$$(\mathfrak{R}_1 + \sqrt{\omega}\mathfrak{R}_2) > 0$$

That requires fulfilling the relation $Z_{0d} > \sqrt{\frac{1}{2}}$. Now we will study the excitation of instability in

different cases; **strong inhomogeneity for ion**, i.e., $(\frac{\omega_{n[two \cdot ions]}}{\omega_0} \gg 1)$, that means $\mathfrak{R}_1 > 0$; and **weak**

inhomogeneity for ion, i.e., $(\frac{\omega_{n[two \cdot ions]}}{\omega_0} \ll 1)$, that means $\mathfrak{R}_1 < 0$.

Consequently, it is clear from (10) that, a great gradient in ion density may be a method for depression of Buneman's instability.

4. Conclusions

In this work the two ions species are found to play a crucial role on Buneman's instability (growing or damping of Buneman's instability) in isothermal and non-isothermal dusty plasma. Besides, in presence of two ions species, the temperature and dusts particle size also play a very important and significant role in controlling such instability. However, Buneman's instability appears faster in multi ion species and dust plasma specially if we change in the inhomogeneity in density of plasma.

Growth rate and frequency of Buneman's instability are strongly affected by the masses of the two ions species (i.e., much growing of such instability).

It can be considered that a large change in multi ions density gradient (MIDG) is a means of excitation such instability states. From an experimental point of view, this method plays an important role when studying the disturbances resulting from the gradual change in the temperature of the ions DIII-D [14], and studying the disturbances resulting from the gradual change in the temperature of the ions in converter tokamak edge (L-H transition)[17].

Growing or depressing of instability in two cases; for strong ion inhomogeneity and weak ion inhomogeneity, are investigated and showed that, multi ion in a large density gradient may be a method for

depression of Buneman's instability (i.e., one of main parameters controlling the growth rate γ_k , and frequency ω_k).

The case of strong perturbations $(\frac{\Delta u}{u_{cr}}, \frac{\Delta \omega}{\omega}, \frac{\Delta k}{k}, \theta) \gg 1$ is of novel consideration, which may be considered in forthcoming treatment. It will be also of great interest to upgrade the work by considering the quantum effects on depression and excitation of BI in Two Ions Species Plasma.

Acknowledgement

This research was funded by the Deanship of Scientific Research at Princess Nourah Bint Abdulrahman University through the Fast-track Research Funding Program. Also, I would like to express my deep and sincere gratitude to my research supervisor Prof. Sh. M. Khalil (Plasma Physics and Nuclear Fusion Dept., Nuclear Research Center at Egyptian Atomic Energy Authority) for fruitful discussions and guidance during different stages of this work.

REFERENCES

- [1] Sh. M. Khalil and Y.A. Sayed, Contribution Plasma Phys., 34 (1994) 683.
- [2] Sh. M. Khalil and H. Al-Yousef, FIZIKA A, 19(2010)1.
- [3] J. F. Drake, et. al., Bull Am. Phys. Soc., 46 (2001)144.
- [4] V. Rosenberg and P. Shukla, J. Plasma Phys. 70(2004)317.
- [5] I.A. El-Naggar, Sh. M Khalil and V.L. Sizonenko, J. Plasma Physics, 20 (1978)75.
- [6] Sh.M. Khalil and B.F.Mohamed, Contrib. Plasma Phys., 31(1991)513.
- [7] S. Akihiro, T. Mieko, and O. Yukiharu, Journal of Plasma Fusion Res. 4(2001)496.
- [8] M. TOIDA and Y. OHSAWA, Journal of Plasma Physics, 72:6 (2006)895-899 Cambridge University Press.
- [9] G. D. Severn, X. Wang, E. Ko, N. Hershkowitz, Phys Rev Lett. 90(14) (2003)145001.
- [10] M. Nunami, M. Nakata and, S. Toda and H. Sugama, Physics of Plasmas 27(2020) 052501.
- [11] S. Akihiro, T. Mieko and O. Yukiharu, J. Plasma Fusion Res. SERIES, Vol.4 (2001) 49499
- [12] T.X. Zhang, M. Toida and Y. Ohsawa, J. Phys. Soc. Jpn. 62 (1993) 2545.
- [13] S. Nakazawa, T.X. Zhang and Y. Ohsawa, Solar Physics 166(1996)159.
- [14] C.S. Chang, and S. Ku, Phys. Plasmas, 15 (2008)062510.
- [15] Y. Omura, W. J. Heikkila et al., J. Geophys. Res., A5:108(2003) 1197.
- [16] C.S. Chang, and S. Ku., Phys. Plasmas, 15 (2008)062510.
- [17] C.S. Chang and et al, Phys. Plasmas, 16(2009)056108.