# THE EFFECT OF LASER BEAM INTENSITY ON SELF-FOCUSING AND TERAHERTZ RADIATION AT LOW FREQUENCY RANGE (0.1 AND 0.5) THZ

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**Abstract**

This research presents a study to explain the nonlinear self-focusing of Gaussian laser beam with right circular polarization (RCP) in the presence of longitudinal magnetic field, then propagation in plasma. Due to self-focusing of (RCP) laser beam inside plasma, the intensity inside the system will reach $10^{18}$ W.cm$^{-2}$ or more which is enough to excite a terahertz radiation by relativistic nonlinearity. The terahertz radiation generation is depending on the down conversion of three wave mixing technique and on the fulfilling the phase matching conditions between pump waves (laser beam), plasma wave and generated terahertz wave. By designing appropriate Matlab programs, the final equations of self-focusing effect and terahertz generation have been solved numerically. The calculations show that the increasing of both the initial intensity and the initial radius of the laser beam are leading to increase the nonlinear self-focusing and thus the terahertz radiation generation. One of the main significant result of this study is that increasing of initial laser intensity and laser beam radius will lead to more stability of self focusing of laser beam and therefore more stability of excited terahertz radiation.

**Keywords:** Self-focusing, Terahertz radiation, plasma wave, Relativistic nonlinearity.

**1-Introduction**

Terahertz (THz) technology is relatively new, and has only seen significant progress in the last three decades [1, 2]. Nevertheless, the wide range of possible applications of today's THz technology stimulate intense attention of specialists in various fields, such as imaging, sensing, quality control, wireless communication, and basic science [3-9].

In this research, operating the relativistic force, one may investigate the nonlinear self-focusing of an intense laser beam through plasma in presence of external configuration of static magnetic field longitudinally with respect to laser beam. Appropriated expressions will be introduced in section 2 to calculate the nonlinear dielectric tensor of magnetized plasma, and the beam width parameter equations of laser beam self-focusing in both longitudinal magnetic fields will derive. Section 3 is a bout, the Generation Technique Terahertz radiation. While section 4 will be a rich discussion of the numerical results, and final conclusions that will introduce, in presence of typical parameters of the laser beam, plasma and magnetic fields.

**2 -Laser Beam Self Focusing in Relativistic Nonlinearity**

Suppose that a uniform magnetized plasma of equilibrium electron density $n_0$ submerged in static magnetic field $B_0$ aligned along z-direction. The electric field vector $\vec{E}_{0+}$ of a right circular polarized electromagnetic wave propagating along z-direction via the magneto plasma can be written as [10] :

$$\vec{E}_{0+} = \vec{A}_{0+}(x,y,z)\exp i(\omega_0 t - k_{0+} z)\ldots\ldots(1)$$

Where $\vec{A}_{0+}(x,y,z) = E_x + iE_y$ is the electric field amplitude, $\omega_0$ and $k_{0+}$ are the angular frequency and wave vector respectively, and the later related with dielectric constant $\varepsilon_{0+}$ by.

$$\varepsilon_{0+} = k_{0+}^2 (\frac{c^2}{\omega_0^2})$$

The relativistic motion equation in presence high intensity laser is:

$$m\frac{\partial}{\partial t}(\gamma\vec{\upsilon}(x,y)) = -e\vec{E} - \frac{e}{c}(\vec{\upsilon}(x,y)\times\vec{B}_0)\ldots\ldots(2)$$

where $\gamma$, $\vec{\upsilon}(x,y)$ and $\vec{B}_0$ are the relativistic factor denoting electron mass increasing, the oscillation velocity imparted from laser beam and external magnetic field .

When the pulse width $\tau_L$ longer than $(\omega_{pe})^{-1}$ and shorter than $(\omega_{pi})^{-1}$, where $\omega_{pe}$ , $\omega_{pi}$ are the electron and ion frequencies in plasma respectively ,one can consider that the ion is immobile , while the moving will confirm on the electron only with oscillating electron velocity $\upsilon_{0+}$ of extraordinary mode which can be written ,depending on eq.(2),as:

$$\vec{\upsilon}_{0+} = \vec{\upsilon}_x + i\vec{\upsilon}_y = \frac{ie\vec{E}_{0+}}{m_e\gamma\omega_0(1-\frac{\omega_{ce}}{\gamma\omega_0})}$$

where $\omega_{ce} = \frac{e|B_0|}{m_e\gamma c}$ electron cyclotron frequency and $\gamma = (1-\frac{\upsilon_e^2}{c^2})^{-\frac{1}{2}}$

here $\upsilon_e^2 = \frac{1}{2}(\upsilon_x\cdot\upsilon_x^* + \upsilon_y\cdot\upsilon_y^*)$ [11] thus the relativistic factor $\gamma$ will be:

$$\gamma \cong 1 + \frac{1}{8}\cdot(\frac{e}{m_e c\omega_0})^2\cdot\frac{A_{0+}\cdot A_{0+}^*}{(1-\frac{\omega_{ce}}{\omega_0})^2} = 1 + \alpha_+ A_{0+}\cdot A_{0+}^*\ldots\ldots(3)$$

Proposing $\gamma^2 \cong 1$

Relativistic nonlinearity factor $\alpha_{+} = \frac{e^2}{8m_e^2 c^2 \omega_0^2} \cdot \frac{1}{(1-\frac{\omega_{ce}}{\omega_0})^2}$ will become zero at non-relativistic system (i.e. $\gamma = 1$).

The general wave equation of electromagnetic wave which is propagating magneto plasma can be given as:

$$\nabla^2 \vec{E} - \nabla\left(\vec{\nabla} \cdot \vec{E}\right) + \frac{\omega^2}{c^2} \underline{\underline{\varepsilon}} \cdot \vec{E} = 0 \qquad (4)$$

In relativistic regime, the components of the dielectric constant tensor $\underline{\underline{\varepsilon}}$ will be as following:

$$\varepsilon_{xx} = \varepsilon_{yy} = 1 - \frac{\omega_{pe}^2}{\omega_0^2 \gamma \left(1 - \frac{\omega_{ce}^2}{\omega_0^2 \gamma^2}\right)} \qquad (5)$$

$$\varepsilon_{xy} = -\varepsilon_{yx} = \frac{-i\left(\frac{\omega_{pe}}{\omega_0 \gamma}\right)^2 \left(\frac{\omega_{ce}}{\omega \gamma}\right)}{\left(1 - \frac{\omega_{ce}^2}{\omega_0^2 \gamma^2}\right)} \qquad (6)$$

$$\varepsilon_{xz} = \varepsilon_{yz} = \varepsilon_{zx} = \varepsilon_{zy} = 0 \qquad (7)$$

$$\varepsilon_{zz} = 1 - \frac{\omega_{pe}^2}{\omega_0^2 \gamma^2} \qquad (8)$$

While the effective dielectric constant corresponding to right circular polarized electromagnetic wave $\varepsilon_{+}$ will take the following formula:

$$\varepsilon_{+} = \varepsilon_{xx} - i\,\varepsilon_{xy} = 1 - \frac{\frac{\omega_{pe}^2}{\omega_0^2 \gamma}}{\left(1 - \frac{\omega_{ce}}{\omega_0 \gamma}\right)} \qquad (9)$$

Where $\omega_{pe} = \left(\frac{4\pi n_e e^2}{m_e}\right)^{\frac{1}{2}}$ is the electron plasma frequency?

Using eq.(3) the effective dielectric constant $\varepsilon_{+}$ cab be written as following:

$$\varepsilon_{+}=1-\frac{\left(\frac{\omega_{pe}}{\omega_0}\right)^2}{\left(1-\frac{\omega_{ce}}{\omega_0}\right)}+\frac{\left(\frac{\omega_{pe}}{\omega_0}\right)^2}{\left(1-\frac{\omega_{ce}}{\omega_0}\right)^2}\alpha_{+}A_{0+}A_{0+}^{*}\ldots\ldots\ldots\ldots\text{(10)}$$

It is obvious that the effective dielectric constant $\varepsilon_{+}$ consists of a linear part $\varepsilon_{0+}$ and a nonlinear part $\phi_{+}\left(A_{0+}A_{0+}^{*}\right)$ ,where the latter is appearing as a result of relativistic electron mass increase, respectively as following:

$$\varepsilon_{0+}=1-\frac{\left(\frac{\omega_{pe}}{\omega_0}\right)}{\left(1-\frac{\omega_{ce}}{\omega_0}\right)}\ldots\ldots\ldots\ldots\ldots\ldots\ldots\text{(11)}$$

$$\phi_{+}=\varepsilon_{2+}A_{0+}A_{0+}^{*}\ldots\ldots\ldots\ldots\ldots\ldots\ldots\text{(12)}$$

$$\varepsilon_{2+}=\frac{1}{8}\left(\frac{e}{mc\omega_0}\right)^2\frac{\left(\frac{\omega_{pe}}{\omega_0}\right)^2}{\left(1-\frac{\omega_{ce}}{\omega_0}\right)^4}\ldots\ldots\ldots\ldots\ldots\ldots\ldots\text{(13)}$$

One can consider that the electromagnetic wave inside magneto plasma as transverse wave since its field vary along external magnetic field(i.e. z-direction) larger than its variation via wave front plane(i.e. x-y direction)[12], so no space charge occur and thus:

$$\vec{\nabla}\cdot\vec{D}=\vec{\nabla}\cdot\left(\underline{\underline{\varepsilon}}\vec{E}\right)=0\ldots\ldots\ldots\ldots\ldots\ldots\ldots\text{(14)}$$

Using eq.(14) with components of dielectric tensor eqs.(5-8) one can get:

$$\frac{\partial E_z}{\partial z}\cong-\frac{1}{\varepsilon_{zz}}\left[\varepsilon_{xx}\left(\frac{\partial E_x}{\partial x}+\frac{\partial E_y}{\partial y}\right)+\varepsilon_{xy}\left(\frac{\partial E_y}{\partial x}-\frac{\partial E_x}{\partial y}\right)\right]\ldots\ldots\ldots\ldots\text{(15)}$$

Equation (15) is the important approximation (zero-order approximation) help us to solve general wave equation (eq. 4),and thus the differential equation of the circular polarized electric field amplitude $A_{0+}$ will be :

$$\frac{\partial^2 A_{0+}}{\partial z^2}+\frac{1}{2}\left(1+\frac{\varepsilon_{0+}}{\varepsilon_{0zz}}\right)\left(\frac{\partial^2}{\partial x^2}+\frac{\partial^2}{\partial y^2}\right)A_{0+}+\frac{\omega_0^2}{c^2}\left(\varepsilon_{0+}+\varepsilon_{2+}A_{0+}A_{0+}^{*}\right)A_{0+}=0\ldots\ldots\text{(16)}$$

Where the product of nonlinear part with $\frac{\partial^2 A_{0+}}{\partial x^2}$ or $\frac{\partial^2 A_{0+}}{\partial y^2}$ have been neglected [13]. To solve eq. (16) assuming $A_{0+} = A'_{0+} \exp i(\omega_0 t - k_{0+} z)$ where $A'_{0+}$ is complex amplitude to get:

$$-2ik_{0+}\frac{\partial A'_{0+}}{\partial z}+\frac{1}{2}\left(1+\frac{\varepsilon_{0+}}{\varepsilon_{0zz}}\right)\left(\frac{\partial^2}{\partial x^2}+\frac{\partial^2}{\partial y^2}\right)A'_{0+}+\frac{\omega_0^2}{c^2}(\varepsilon_{2+}A'_{0+}A'^{*}_{0+})A'_{0+}=0........(17)$$

Proposing a two dimensional Gaussian beam (i.e. $\frac{\partial}{\partial y}=0$) and introducing an eikonal $A'_{0+} = A^0_{0+} \exp ik_{0+}S_+$ , where $A^0_{0+}$ and $S_+$ are a real function and the phase of the laser beam inside magnetic plasma, hence eq.(17), after separating real and imaginary parts, can be written as following [13]:

$$2\frac{\partial S_+}{\partial z}+\frac{1}{2}\left(1+\frac{\varepsilon_{0+}}{\varepsilon_{0zz}}\right)\left(\frac{\partial S_+}{\partial x}\right)^2-\frac{1}{2k_{0+}^2A^0_{0+}}\left(1+\frac{\varepsilon_{0+}}{\varepsilon_{0zz}}\right)\frac{\partial^2 A^0_{0+}}{\partial x^2}=\frac{\varepsilon_{2+}}{\varepsilon_{0+}}\left(A^0_{0+}\right)^2.......(18)$$

$$\frac{\partial\left(A^0_{0+}\right)^2}{\partial z}+\frac{1}{2}\left(A^0_{0+}\right)^2\left(1+\frac{\varepsilon_{0+}}{\varepsilon_{0zz}}\right)\frac{\partial^2 S_+}{\partial x^2}+\frac{1}{2}\left(1+\frac{\varepsilon_{0+}}{\varepsilon_{0zz}}\right)\frac{\partial S_+}{\partial x}\frac{\partial\left(A^0_{0+}\right)^2}{\partial x}=0........(19)$$

In the paraxial ray approximation $S_+$ can be expanded to $S_+ = \frac{1}{2}x^2\beta_+(z)+\phi(z)$

Introducing initially Gaussian beam $\left(A^0_{0+}\right)^2 = \frac{E_{00}^2}{f_+}\exp\left(-\frac{x^2}{x_0^2 f_+^2}\right)$ and substituting $S_+$ in eq. (19), $\beta(z)$ will take the following formula [14]:

$\beta_+(z) = 2\left(1+\frac{\varepsilon_{0+}}{\varepsilon_{0zz}}\right)^{-1}\frac{1}{f_+}\frac{df_+}{dz}$ Where $f_+$ represents the beam width parameter.

Using $A^0_{0+}$ and $\beta_+(z)$ values in eq.(19) and assuming initially plane wave front condition($f_+ = 1$ and $\frac{df_+}{dz}=0$ at $z=0$) we obtain :

$$\frac{d^2 f_+}{dz^2}=\frac{1}{4}\left(1+\frac{\varepsilon_{0+}}{\varepsilon_{0zz}}\right)^2\frac{1}{k_{0+}^2x_0^4f_+^3}-\frac{1}{2}\left(1+\frac{\varepsilon_{0+}}{\varepsilon_{0zz}}\right)\left(\frac{\varepsilon_{2+}E_{00}^2}{\varepsilon_{0+}}\right)\frac{1}{x_0^2f_+^2}.......(20)$$

This equation represents the variation of laser beam diameter when it is propagating inside plasma. First term and second term on right hand side of equation (20) show the natural diffraction phenomenon and self focusing effect respectively.

**3-The Generation Technique of Terahertz radiation**

The generation mechanism of the terahertz radiation $(E_{t+}, \omega_t, k_t)$ depends upon the nonlinear coupling between high intense laser beam $(E_{0+}, \omega_0, k_{0+})$ and density perturbation $(E_1, \omega_1, k_1)$ at phase match conditions :

Energy conservation condition $\omega_0 = \omega_1 + \omega_t$,

and momentum conservation condition $\vec{k}_{0+} = \vec{k}_1 + \vec{k}_t$

where $E_{t+}$ and $E_1$ can be written as:

$$E_1 = A_1(z)\exp i\left(\omega_1 t - k_1 z\right)$$

$$E_{t+} = A_{t+}(x, y, z)\exp i\left(\omega_t t - k_t z\right) \qquad (21)$$

Where $A_{t+}(x, y, z) = E_{tx} + iE_{ty}$ is amplitude of right circular polarized terahertz field?

The relativistic oscillating velocity $\upsilon_1 = -\frac{ieE_1}{m_e \gamma \omega_1}$ obtained by plasma wave field is related with density perturbation as:

$\upsilon_1 = \frac{\omega_1}{k_1}\mu$ Where $\mu = \frac{n_p}{n_e}$ is normalized perturbation density representing the ratio between perturbed density $n_p$ and background plasma density $n_e$

The interaction between electromagnetic fields and plasma wave field can be governed by:

1- Continuity equation (mass conservation) $\frac{\partial n_j}{\partial t} = -\nabla \cdot \left(n_j \vec{\text{v}}_j\right)$

2- Momentum equation $m_j \gamma \frac{\partial \vec{\upsilon}_j}{\partial t} + m_j\left(\vec{\upsilon}_j \cdot \nabla\right)\vec{\upsilon}_j = -e\vec{E}_{t+} - \frac{e}{c}\vec{\upsilon}_j \times \vec{B}_0$

Where $n_j, m_j, \upsilon_j$ are the particle density, the mass and the velocity of species *j*= *i* , *e*

Using the continuity equation, the total current density $\vec{J}_{t+}$ because of interaction of high intense laser beam with perturbed plasma achieving terahertz radiation will be:

$$\vec{J}_{t+} = \vec{J}_{1+} + \vec{J}_{2+} \qquad (22)$$

Where linear current density $\vec{J}_{1+}$ is :

$$\vec{J}_{1+} = -en_0\vec{\upsilon}^{e}_{1+} + en_0\vec{\upsilon}^{i}_{1+} \qquad (23)$$

and nonlinear current density $\vec{J}_{2+}$ is :

$$J_{2+} = -en_p^*\vec{\upsilon}_{0+} - en_0\vec{\upsilon}_{2+}^e \qquad (24)$$

Where $\vec{\upsilon}_{1+}^e, \vec{\upsilon}_{1+}^i$ represent the electron and ion linear velocities which can be extracted by solving momentum equation of the right circular polarized low frequency wave $E_{t+}$ as following:

$$\vec{\upsilon}_{1+}^e = \frac{ie\vec{E}_{t+}}{m_e\gamma\omega_t\left(1-\frac{\omega_{ce}}{\omega_t\gamma}\right)} \qquad (25)$$

$$\vec{\upsilon}_{1+}^i = \frac{ie\vec{E}_{t+}}{m_e\gamma\omega_t\left(1+\frac{\omega_{ci}}{\omega_t\gamma}\right)} \qquad (26)$$

Where $\omega_{ci} = \frac{eB_0}{m_i c}$ is non-relativistic ion cyclotron frequency?

Introducing $\vec{B}_0 = \left(\frac{c\vec{k}_{0+}}{\omega_0}\right)\times\vec{E}_{0+}$ in momentum equation, the nonlinear velocity $\vec{\upsilon}_{2+}$ corresponding to the interaction of ripple density with laser field in magneto plasma is:

$$\vec{\upsilon}_{2+} = \frac{-ie\vec{E}_{0+}\left(\frac{\omega_{ce}}{\gamma}\right)k_{0+}\upsilon_1^*}{m_e\gamma\omega_0^2\omega_t\left(1-\frac{\omega_{ce}}{\omega_0\gamma}\right)\left(1-\frac{\omega_{ce}}{\omega_t\gamma}\right)} \qquad (27)$$

At last the quiver electron velocity $\vec{\upsilon}_{0+}$ in laser field (see eq.(2))is:

$$\vec{\upsilon}_{0+} = \frac{ie\vec{E}_{0+}}{m_e\gamma\omega_0\left(1-\frac{\omega_{ce}}{\omega_0\gamma}\right)} \qquad (28)$$

Substituting equations (24), (25) in eq. (22) and equations (26), (27) in eq. (23), thus the linear and nonlinear current densities will become:

$$\vec{J}_{1+} = \frac{-i\,\omega_{pe}^2\vec{E}_{t+}}{4\pi\gamma\omega_t\left(1-\frac{\omega_{ce}}{\omega_t\gamma}\right)\left(1+\frac{\omega_{ci}}{\omega_t\gamma}\right)} \qquad (29)$$

$$\vec{J}_{2+} = \frac{-i\,\omega_{pe}^2\mu^*}{4\pi\gamma\omega_0\left(1-\frac{\omega_{ce}}{\omega_0\gamma}\right)}\left(1-\frac{\omega_1 k_{0+}\omega_{ce}}{\omega_0 k_1\gamma\omega_t\left(1-\frac{\omega_{ce}}{\omega_t\gamma}\right)}\right)\vec{E}_{0+} \qquad (30)$$

In the magneto plasma ambient, the total current density via terahertz field can be governed by the following wave equation (Shukla & Sharma) [15]:

$$\nabla^2 \vec{E}_{t+}^{\,2} - \frac{1}{c^2}\frac{\partial^2 \vec{E}_{t+}}{\partial t^2} = \frac{4\pi}{c^2}\frac{\partial \vec{J}_{t+}}{\partial t} \quad \text{.........}(31)$$

Considering ion is immobile, thus its contribution in nonlinear interaction can be ignored. Putting equations (22, 28, and 29) in eq. (30) to get:

$$\frac{d^2\vec{E}_{t+}}{dz^2} + \frac{\omega_t^2}{c^2}\left[1 - \frac{\omega_{pe}^2}{\omega_t^2\gamma\left(1-\frac{\omega_{ce}}{\omega_t\gamma}\right)}\right]\vec{E}_{t+} = \frac{\omega_{pe}^2\omega_t\mu^*}{c^2\omega_0\gamma\left(1-\frac{\omega_{ce}}{\omega_0}\right)}\left[1-\frac{\omega_1 k_{0+}\omega_{ce}}{\omega_0 k_1\omega_t\gamma\left(\frac{\omega_{ce}}{\omega_t\gamma}-1\right)}\right]\vec{E}_{0+}\text{......}(32)$$

Calculating relativistic factor $\gamma = 1+\alpha_+ A_{0+}A_{0+}^*$ by using similar technique in section 2 [16] thus eq. (31) will take the following formula:

$$\frac{d^2\vec{E}_{t+}}{dz^2} + \left[\frac{\omega_t^2}{c^2}\left(1-\frac{\omega_{pe}^2}{\omega_t^2\left(1-\frac{\omega_{ce}}{\omega_t}\right)}\right) + \alpha_{t+}A_{0+}A_{0+}^*\right]\vec{E}_{t+} = \left[\frac{\omega_{pe}^2\omega_t\mu^*}{c^2\omega_0\left(1-\frac{\omega_{ce}}{\omega_0}\right)}\left(1-\frac{\omega_1 k_{0+}\omega_{ce}}{\omega_0 k_1\omega_t\left(\frac{\omega_{ce}}{\omega_t\gamma}-1\right)}\right)+\alpha_{tt+}A_+A_{0+}^*\right]\vec{E}_{0+}\text{......}(33)$$

Where $\alpha_{t+},\alpha_{tt+}$ represent relativistic increasing mass contribution terms, which can be written as following:

$$\alpha_{t+} = \frac{\omega_{pe}^2}{c^2\left(1-\frac{\omega_{ce}}{\omega_t}\right)^2}\alpha_+ A_{0+}A_{0+}^*$$

$$\alpha_{tt+} = \left(\frac{\omega_{pe}^2\left(\frac{2\omega_{ce}}{\omega_0}-1\right)}{\omega_0\left(1-\frac{\omega_{ce}}{\omega_0}\right)^2} - \frac{\omega_1 k_{0+}\omega_{ce}\omega_{pe}^2}{\omega_0^2 k_1\omega_t\left(\frac{\omega_{ce}}{\omega_t}-1\right)\left(1-\frac{\omega_{ce}}{\omega_0}\right)}\left(\frac{\omega_{ce}}{\omega_t\left(\frac{\omega_{ce}}{\omega_t}-1\right)}+\frac{\omega_{ce}}{\omega_0\left(1-\frac{\omega_{ce}}{\omega_0}\right)}-2\right)\right)\alpha_+ A_{0+}A_{0+}^*$$

$\alpha_+$ has the same meaning as in section 3 .

It is obvious that the non relativistic case will be satisfied when $\alpha_{t+},\alpha_{tt+}$ are vanished, and to obtain terahertz generation intensity ,the eq.(33) have be solved numerically.

**FIGURES CAPTION**

Figure 1: Variation of beam width parameter $f_+$ along the normalized propagation distance $\zeta_+$ is dependent upon variation of normalized vector potential (intensity laser beam).

Figure 2: Variation of normalized THz radiation amplitude at 0.1 THz frequency along the normalized propagation distance $\zeta_+$ is dependent upon variation of normalized vector potential (intensity laser beam).

Figure 3: Variation of normalized THz radiation amplitude ($E_t/E_{00}$) at 0.5 THz frequency along the normalized propagation distance $\zeta_+$ is dependent upon variation of normalized vector potential(intensity laser beam).

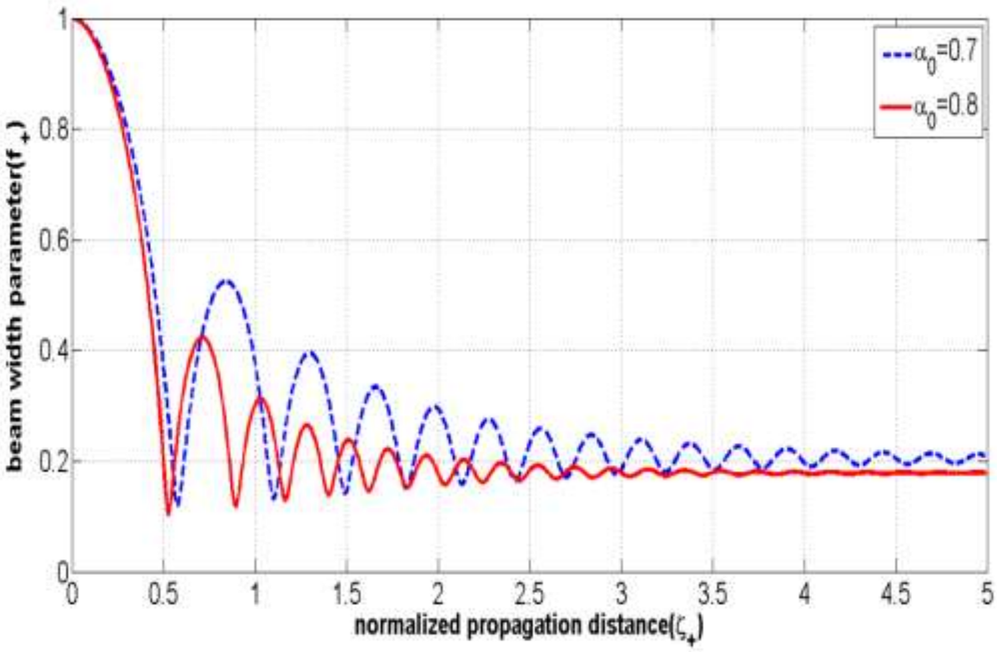


**Figure 1**: Variation of beam width parameter $f_+$ along the normalized propagation distance $\zeta_+$ is dependent upon variation of normalized vector potential (intensity laser beam).

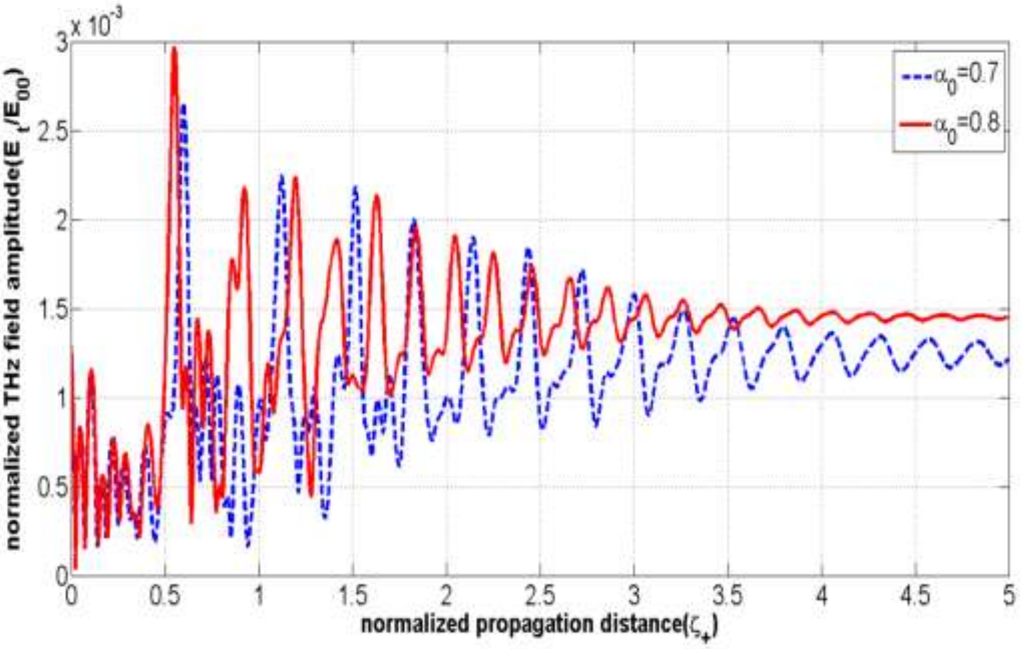


**Figure 2 :** Variation of normalized THz radiation amplitude at 0.1 THz frequency along the normalized propagation distance $\zeta_+$ is dependent upon variation of normalized vector potential (intensity laser beam).

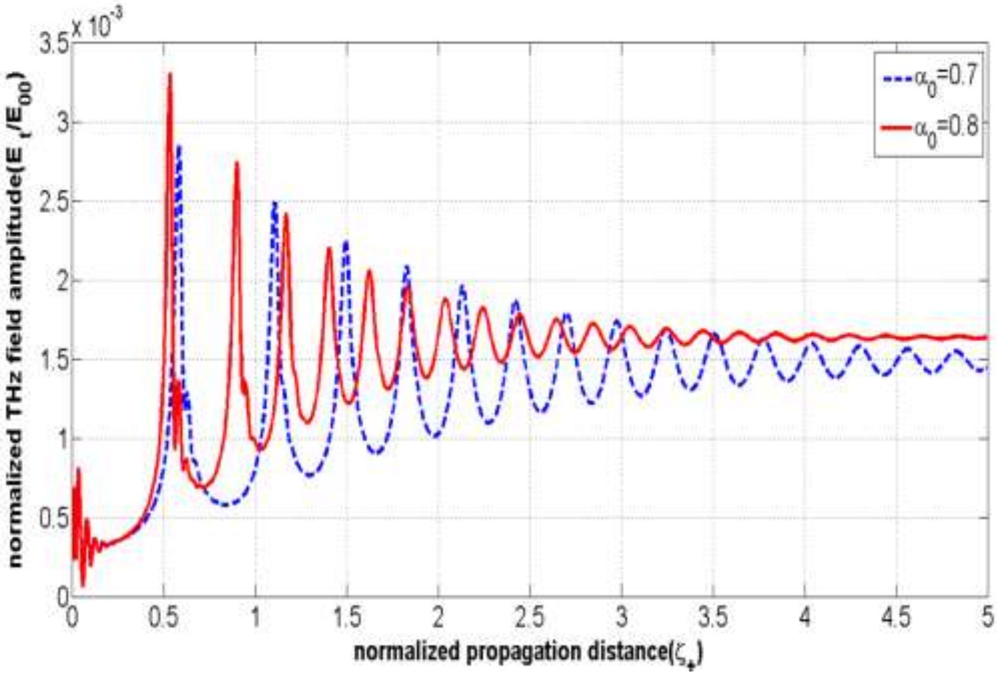


**Figure 3** : Variation of normalized THz radiation amplitude ($E_t/E_{00}$) at 0.5 THz frequency along the normalized propagation distance $\zeta_+$ is dependent upon variation of normalized vector potential(intensity laser beam).

## 4 -RESULT DISCUSSIONS AND CONCLUSIONS

In this article, the typical parameters of laser and plasma are introduced as the following:

The wavelength of pump laser is ($\lambda = 10.6\,\mu m$) corresponding to the frequency ($\nu = 2.8 \times 10^{13}\sec^{-1}$), The laser beam intensities $I = 6.4 \times 10^{16} W/cm^2$ and $8.4 \times 10^{16} W/cm^2$ are corresponding to normalized vector potentials $\alpha_0 = 0.7$ and $0.8$ respectively, it is important to decide that the normalized vector potential are calculated using the following equation [69]:

$\alpha_0 = 0.85 \times 10^{-9}\sqrt{I\lambda}\ \left[ I \left( W/_{cm^2} \right) \text{ and } \lambda(\mu m) \right]$, The initial laser beam radius ($x_0 = (14, 16, 18 \text{ and } 20)\,\mu\text{m}$), the plasma densities are in order of $n_e \approx 7 \times 10^{18}\, cm^{-3}$ corresponding to the plasma frequency $\omega_p \approx 1.4 \times 10^{13}\, rad.\sec^{-1}$, The external longitudinal magnetic field is in order of $B \approx 50\, kG$.

The presence of magnetic field has a significant influence on enhancement of the self-focusing laser beams to be faster and stronger. The external l magnetic longitudinal field geometries have crucial role on the nonlinear self-focusing of Gaussian laser beam. The Generation Technique Terahertz radiation, from introduction laser beam with magnetized plasma that the final equations of laser beam self-focusing (20) and terahertz radiation equation (33), have been solved numerically using Matlab program

In table 1, the relationship between laser beam intensity and the laser beam self-focusing is directly relationship, where the laser beam self-focusing is greater and becomes maximally stabilized with increasing laser beam intensity.

In table 2, the relationship between laser beam intensity and the normalized THz radiation amplitude $\left( E_t/_{E_{00}} \right)$ is direct relationship, where the normalized THz radiation amplitude is increasing and becomes maximally stabilized with increasing of laser beam intensity.

In table 3, the relationship between laser beam intensity and the normalized THz radiation amplitude $\left( E_t / E_{00} \right)$ is direct relationship, where the normalized THz radiation amplitude is more increasing and becomes maximally stabilized with laser beam intensity increasing compare with table 2.

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