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EFFECTS OF THE WIGGLER FIELD ON THE TERAHERTZ RADIATION GENERATED BY INTENSE LASER BEAM IN COLLISIONLESS MAGNETOPLASMA

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In this paper, relativistic effects of the wiggler field on the terahertz (THz) radiation generated by intense laser beam in collisionless magnetoplasma in the attendance of a planar magnetostatic wiggler is studied. Analytical formulation governing the laser spot-size with respect to competition between diffraction and self-focusing terms of laser beam has been derived and the effects of the wiggler field on the variations of beam width parameter and THz field amplitude has been investigated. Numerical simulations show that increasing of wiggler magnetic field leads to reduces of beam width parameter. Indeed, when we employ the magnetic wiggler field, self-focusing in magnetoplasma improve, appropriately. In addition, it was found that by employing wiggler magnetic field, maximum spot-size of the laser beam decreases as a result of laser beam propagating in magnetoplasma. Moreover, it was shown that the THz conversion efficiency significantly enhanced, with increasing of the wiggler field strength. Also, it was found that self-focusing of the laser beam and wiggler magnetic field play crucial roles in process of conversion efficiency.

Keywords: THz radiation generation, Wiggler magnetic field, Self-focusing, Laser spot-size, magnetoplasma.

1. Introduction

Terahertz (THz) spectrum in the range 0.1–10 THz, lying between microwave (MW) and infrared (IR) regions and has many applications in the fields of such as, laser pulse self-focusing[1-5], spectroscopy [1, 6-10], tomography [11-13], remote sensing [14-16], biology and medicine[17-20], quality control[21-24]. Different methods have been applied for the generation of THz using high power lasers. For THz generation, various laser-based techniques by using electro-optic crystals, photoconductive antennas and semiconductors have been employed. The generation of THz radiation with filamentation process has been investigated theoretically and experimentally by many authors. Xie *et al.*[25] investigated coherent control of THz wave generation in ambient air. It was shown that the four-wavemixing rectification in the laser induced plasma is the main mechanism of the THz wave generation in the air plasma through the use of individual control of the ω and 2ω beams. Singh *et al.*[26] presented a theoretical model for efficient terahertz (THz) radiation by self-focused amplitude-modulated laser beam in

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preformed ripple density plasma. It was analyzed that self-focused laser beam can enhance the yield of THz radiation several times as compared with that without self-focusing of laser beam. Chauhan and Parashar [27] studied terahertz (THz) radiation generation by non-linear mixing of lasers, obliquely incident on a plasma slab. It was found that in case of uniform plasma, the sharp density variation at the plasma boundaries leads to radiation generation. Andreeva *et al.*[28] considered ultrabroad terahertz spectrum generation from an air-based filament plasma. It was observed that the contribution from neutrals by four-wave mixing is much weaker and higher in frequency than the distinctive plasma lower-frequency contribution. Antonsen *et al.*[29] studied the excitation of terahertz radiation by laser beams propagating in miniature plasma channels. It was found that for channels and laser beams with parameters that can be realized today, energy conversion rates of a fraction of a joule per centimeter can be obtained. Sheng *et al.*[30] presented some simulation results on the wake emission when the wakefield was driven in the wave breaking regime and driven inside a plasma channel. It was concluded that while the incident beam is at extremely high intensities, the wakefield can break and form a bubble-like structure. HU *et al.*[31] investigated transition-Cherenkov radiation of terahertz generated by super-luminous ionization front in femtosecond laser filament. It was shown the enhanced THz radiation attributes to the better coherent superposition of the radiation field emitted by the dipole-like electron current moving along the laser filament. The organization of this paper is as follows. In section 2, basic equations and physical methods are expressed. In section 3, the effects of the wiggler field on the terahertz radiation generated by intense laser beam interacting with collisionless magnetoplasma in the presence of a planar wiggler has been studied. In section 4, the numerical results and typical parameters of intense laser beam and magnetoplasma are presented. Finally, the conclusions are presented in section 5.

2. Theoretical considerations

The physical configuration we consider is that of an intense laser beam propagating through collisionless magnetoplasma composed of a planar wiggler field $\mathbf{B}_w$. The wiggler field can be expressed as[32],

$$\mathbf{B}_w = B_w(\hat{e}_y \sin(k_w z)) \tag{1}$$

Where B_w and $k_w = 2\pi / \lambda_w$ are amplitude and wavenumber of the wiggler field, respectively. As result, for right-hand polarization of circularly polarized wave propagated along z direction inside magnetoplasma, the electric field vector of $\mathbf{E}_{0+}$ given by[33],

$$\mathbf{E}_{0+} = \mathbf{A}_{0+} e^{i(\Omega_0 t - k_{0+} z)} \tag{2}$$

Here, $\mathbf{A}_{0+} = \mathbf{E}_x + i\mathbf{E}_y$ the electric field amplitude, Ω_0 is angular frequency, $k_{0+} = \sqrt{\varepsilon_{0+}\Omega_0^2 / c^2}$ is wave vector, and c denotes the speed of light in vacuum. As known, the relativistic motion equation for electrons is,

$$m_{0e}\gamma_e \frac{\partial \mathbf{v}_e}{\partial t} = -e[\mathbf{E} + (\mathbf{v}_e \times \mathbf{B})] \tag{3}$$

where $\mathbf{v}_e$ is the electron velocity, m_{0e} is the electron rest mass, $\gamma_e = (1 - v_{0+}^2 / c^2)^{-\frac{1}{2}}$ is the relativistic Lorentz factor of electron, and $\mathbf{E}, \mathbf{B}$ are electric and magnetic fields of electromagnetic wave respectively. Employing Eq.(2) electron-oscillating velocity (v_{0+}), for right-hand polarization of circularly polarized wave of intense laser beam in the presence of planar wiggler is obtained as following,

$$\mathbf{V}_{0+} = \mathbf{V}_x + i\mathbf{V}_y = \frac{ie\mathbf{E}_{0+}}{\gamma_e m_{0e}\Omega_0 \left(1 - \dfrac{\Omega_w(\hat{e}_y \sin(k_w z))}{\gamma_e \Omega_0}\right)} \tag{4}$$

in which $\Omega_w = eB_{0w} / m_{0e}c$ is the wiggler frequency. According to Ref.[34], the relativistic Lorentz factor of electron assumed ($\gamma_e - 1 << 1$). Therefore, γ_e can be written as follows,

$$\gamma_e \cong 1 + \frac{1}{2}\left(\frac{e}{m_{0e}c\Omega_0}\right)^2 \left(\frac{A_{0+}A_{0+}^*}{\left(1 - \dfrac{\Omega_w(\hat{e}_y \sin(k_w z)}{\Omega_0}\right)^2}\right) = 1 + \alpha_+ A_{0+}A_{0+}^* \tag{5}$$

In the above equation the relativistic non-linearity factor $\alpha_+ = (e^2 / 2m_{0e}^2 c^2 \Omega_0^2)(1 / (1 - \Omega_w(\hat{e}_y \sin(k_w z)) / \Omega_0)^2)$ will be zero at non-relativistic regime. The electromagnetic wave equation of intense laser beam propagated through magnetized plasma derived as below,

$$\nabla^2 \mathbf{E} - \nabla(\nabla.\mathbf{E}) + \frac{\Omega^2}{c^2}\underline{\underline{\varepsilon}}\mathbf{E} = 0 \tag{6}$$

where $\underline{\underline{\varepsilon}} = \begin{vmatrix} \varepsilon_{xx} & \varepsilon_{xy} & \varepsilon_{xz} \\ \varepsilon_{yx} & \varepsilon_{yy} & \varepsilon_{yz} \\ \varepsilon_{zx} & \varepsilon_{zy} & \varepsilon_{zz} \end{vmatrix}$ is dielectric constant tensor which in relativistic regime the components of it tensor will be written as following,

$$\varepsilon_{xx}=\varepsilon_{yy}=1-\frac{\Omega_p^2}{\Omega_0^2\gamma_e(1-\frac{(\Omega_w(\hat{e}_y\sin(k_w z)))^2}{\Omega_0^2\gamma_e{}^2})}\tag{7}$$

$$\varepsilon_{xy}=-\varepsilon_{yx}=-\frac{i(\frac{\Omega_p^2\Omega_w(\hat{e}_y\sin(k_w z))}{\Omega_0^3\gamma_e^2})}{(1-\frac{(\Omega_w(\hat{e}_y\sin(k_w z)))^2}{\Omega_0^2\gamma_e^2})}\tag{8}$$

$$\varepsilon_{zz}=1-\frac{\Omega_p^2}{\gamma_e\Omega_0^2},\quad \varepsilon_{xz}=\varepsilon_{yz}=\varepsilon_{zx}=\varepsilon_{zy}=0.\tag{9}$$

Thus, for the effective dielectric constant in right-hand polarization of circularly polarized wave of intense laser beam, it is obtained,

$$\varepsilon_{+}=\varepsilon_{xx}-i\varepsilon_{xy}=(1-\frac{(\frac{\Omega_p^2}{\Omega_0^2\gamma_e})}{(1-\frac{\Omega_w(\hat{e}_y\sin(k_w z))}{\Omega_0\gamma_e})})\tag{10}$$

Here, $\Omega_p=\sqrt{n_{0e}e^2/\varepsilon_0 m_{0e}}$ is plasma frequency. Substituting Eq.(5) into Eq.(10), will have,

$$\varepsilon_{+}=1-\frac{(\frac{\Omega_p^2}{\Omega_0^2})}{(1-\frac{\Omega_w(\hat{e}_y\sin(k_w z))}{\Omega_0})}+\frac{(\frac{\Omega_p^2}{\Omega_0^2})(\alpha_{+}A_{0+}A_{0+}^{*})}{(1-\frac{\Omega_w(\hat{e}_y\sin(k_w z))}{\Omega_0})}\tag{11}$$

In fact, when laser beam propagates through plasma, the effective dielectric constant of it changes as a result of relativistic electron mass increase .Therefore, now has a linear part besides a non-linear part where it is expressed as,

$$\varepsilon_{+}=1-\frac{(\frac{\Omega_p^2}{\Omega_0^2})}{(1-\frac{\Omega_w(\hat{e}_y\sin(k_w z))}{\Omega_0})}\tag{12}$$

$$\phi_{+}=\varepsilon_{2+}A_{0+}A_{0+}^{*}\tag{13}$$

$$\varepsilon_{2+} = \frac{e^2}{2c^2 m_{0e}^2 \Omega_0^2} \frac{(\frac{\Omega_p}{\Omega_0})^2}{(1 - \frac{\Omega_w (\hat{e}_y \sin(k_w z))}{\Omega_0})^4} \tag{14}$$

Given that the electromagnetic wave propagating within magnetoplasma is assumed a transverse wave and because variations of field along z direction is greater than variations of wave front plane[35] thus , there is no any space charge, and will have,

$$\mathbf{\nabla.D} = \mathbf{\nabla}.(\underline{\underline{\varepsilon}}\mathbf{E}) = 0 \tag{15}$$

Conjugating Eq.(15) with dielectric tensor components, it is achieved,

$$\frac{\partial E_z}{\partial z} \cong -\frac{1}{\varepsilon_{zz}}[\varepsilon_{xx}(\frac{\partial E_x}{\partial x} + \frac{\partial E_y}{\partial y}) + \varepsilon_{xy}(\frac{\partial E_y}{\partial x} - \frac{\partial E_x}{\partial y})] \tag{16}$$

Inserting Eq.(16) into Eq.(6), to drive the governing equation for the circularly electric field amplitude A_{0+}, the following relation can be derived as,

$$\frac{\partial^2 A_{0+}}{\partial z^2} + \frac{1}{2}(1 + \frac{\varepsilon_{0+}}{\varepsilon_{0zz}})(\frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2})A_{0+} + \frac{\Omega_0^2}{c^2}(\varepsilon_{0+} + \varepsilon_{2+} A_{0+} A_{0+}^*)A_{0+} = 0 \tag{17}$$

Proposing $A_{0+} = A'_{0+} e^{i(\Omega_0 t - k_{0+} z)}$ and inserting it into Eq.(17), will have,

$$\frac{\partial A'_{0+}}{\partial z} - 2ik_0 + \frac{1}{2}(1 + \frac{\varepsilon_{0+}}{\varepsilon_{0zz}})(\frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2})A'_{0+} + \frac{\Omega_0^2}{c^2}(\varepsilon_{2+} A'_{0+} A'_{0+}.)A'_{0+} = 0 \tag{18}$$

Here $A'_{0+} = A_{0+}^0 e^{(ik_{0+} \mathrm{S}_+)}$ is the complex amplitude, and S_+ is phase of laser beam within magnetoplasma. Separating the parts of the real and imaginary of equation (13) leads to as below,

$$2\frac{\partial S_+}{\partial z} + \frac{1}{2}(1 + \frac{\varepsilon_{0+}}{\varepsilon_{0zz}})(\frac{\partial S_+}{\partial x})^2 - \frac{1}{2k_{0+}^2 A_{0+}^0}(1 + \frac{\varepsilon_{0+}}{\varepsilon_{0zz}})(\frac{\partial^2 A_{0+}^0}{\partial x^2}) = \frac{\varepsilon_{2+}}{\varepsilon_{0+}}(A_{0+}^0)^2 \tag{19}$$

$$\frac{\partial (A_{0+}^0)^2}{\partial z} + \frac{1}{2}(A_{0+}^0)^2 (1 + \frac{\varepsilon_{0+}}{\varepsilon_{0zz}})\frac{\partial^2 S_+}{\partial x^2} + \frac{1}{2}(1 + \frac{\varepsilon_{0+}}{\varepsilon_{0zz}})\frac{\partial S_+}{\partial x}\frac{\partial (A_{0+}^0)^2}{\partial x} = 0 \tag{20}$$

It should be noted that in paraxial approximation, phase of laser beam is expanded as following,

$$S_+ = \frac{x^2}{2}\beta_+(z) + \varphi_+(z) \tag{21}$$

where φ_+ is a constant autonomous of x and, β_+^{-1} is parameter which can be described as the curvature radius of laser beam. Now, we introduce Gaussian laser beam with beam radius of primary x_0 as below,

$$(A^0_{0+})^2 = \frac{E_{00}^2}{f_+} e^{-(\frac{x^2}{x_0^2 f_+^2})} \tag{22}$$

Inserting Eq.(21) into Eq.(20), It is obtained as,

$$\beta_+(z) = \frac{2}{f_+}(1+\frac{\varepsilon_{0+}}{\varepsilon_{0zz}})^{-1}\frac{df_+}{dz} \tag{23}$$

Here f_+ is parameter of beam width. Substituting Eqs.(23) and (22) into Eq.(20) and proposing at z=0, $f_+=1$ and $\frac{df_+}{dz}=0$, will have,

$$\frac{\partial^2 f_+}{\partial z^2} = \frac{1}{4k_{0+}^2 x_0^4 f_+^3}(1+\frac{\varepsilon_{0+}}{\varepsilon_{0zz}})^2 - \frac{1}{2x_0^2 f_+^2}(1+\frac{\varepsilon_{0+}}{\varepsilon_{0zz}})(\frac{\varepsilon_{2+}E_{00}^2}{\varepsilon_{0+}}) \tag{24}$$

Relation (24) denotes variations of laser spot-size with respect to competition between diffraction and self-focusing terms of laser beam.

3. THz radiation generation

It is worth noting that THz radiation generation depends upon the non-linear coupling between intense laser beam and rippled density plasma. Furthermore, the phase-matching conditions can be written as,

$$\omega_0 = \omega_1 + \omega_t,\ \mathbf{k}_{0+} = \mathbf{k}_1 + \mathbf{k}_{t+} \tag{25}$$

In fact, the electric fields of intense laser beams can be express as following,

$$\mathbf{E}_1 = E_1 e^{i(\Omega_1 t - k_1 z)} \tag{26}$$

$$\mathbf{E}_{t+} = \mathbf{A}_{t+} e^{i(\Omega_1 t - k_{t+} z)} \tag{27}$$

Here $\mathbf{A}_{t+} = \mathbf{E}_{tx} + i\mathbf{E}_{ty}$ represents the amplitude of right-hand polarization of circularly polarized wave by THz field. In addition, the wave equation of the THz radiation for electric vector $\mathbf{E}_{t+}$ with magnetoplasma is obtained from the Maxwell’s equations as following,

$$\nabla^2\mathbf{E}_{t+} - \frac{1}{c^2}\frac{\partial^2\mathbf{E}_{t+}}{\partial t^2} = \frac{1}{\varepsilon_0 c^2}\frac{\partial\mathbf{J}_{t+}}{\partial t} \tag{28}$$

Here $\mathbf{J}_{t+} = \mathbf{J}_{1+} + \mathbf{J}_{2+}$ is vector of the total current, consists of linear part ($\mathbf{J}_{1+}$) and non-linear part ($\mathbf{J}_{2+}$) as follows,

$$\mathbf{J}_{1+} = -en_0\mathbf{v}^e_{1+} + en_0\mathbf{v}^i_{1+} \tag{29}$$

$$\mathbf{J}_{2+} = -e\tilde{n}^*_p\mathbf{v}_{0+} - en_0\mathbf{v}^e_2 \tag{30}$$

In which $\mathbf{v}_{1+}^{e}$, $\mathbf{v}_{1+}^{i}$ are the velocities of electron and ion respectively. Employing the low frequency electron-momentum balance equation in the presence of wiggler field will have,

$$\mathbf{v}_{1+}^{e}=\frac{ie\mathbf{E}_{t+}}{m_{0e}\gamma_e\Omega_t(1-\frac{\Omega_w(\hat{e}_y\sin(k_wz))}{\gamma_e\Omega_t})} \tag{31}$$

$$\mathbf{v}_{1+}^{i}=\frac{ie\mathbf{E}_{t+}}{m_{0e}\gamma_e\Omega_t(1+\frac{\Omega_w(\hat{e}_y\sin(k_wz))}{\gamma_e\Omega_t})} \tag{32}$$

The non-linear velocity ($\mathbf{v}_{2+}$) in interaction of density ripple with electric field of the laser beam through magnetoplasma given by[36],

$$\mathbf{v}_{2+}=-\frac{ie\mathbf{E}_{0+}k_{0+}v_1^{*}\Omega_w(\hat{e}_y\sin(k_wz))}{2\gamma_e^2m_{0e}\Omega_0^2\Omega_t(1-\frac{\Omega_w(\hat{e}_y\sin(k_wz))}{\gamma_e\Omega_0})(1-\frac{\Omega_w(\hat{e}_y\sin(k_wz))}{\gamma_e\Omega_t})} \tag{33}$$

Moreover, the velocity of the quiver electron in laser field is,

$$\mathbf{v}_{0+}=\frac{ie\mathbf{E}_{0+}}{\gamma_em_{0e}\Omega_0(1-\frac{\Omega_w(\hat{e}_y\sin(k_wz))}{\gamma_e\Omega_0})} \tag{34}$$

Conjugating Eqs.(29)-(34), leads to linear and non-linear current densities as below,

$$\mathbf{J}_{1+}=-\frac{i\Omega_p^2\varepsilon_0\mathbf{E}_{t+}}{\gamma_e\Omega_t(1-\frac{\Omega_w(\hat{e}_y\sin(k_wz))}{\gamma_e\Omega_t})(1+\frac{\Omega_w(\hat{e}_y\sin(k_wz))}{\gamma_e\Omega_t})} \tag{35}$$

$$\mathbf{J}_{2+}=-\frac{i\Omega_p^2\varepsilon_0\mu\mathbf{E}_{0+}^{*}}{2\gamma_e\Omega_0(1-\frac{\Omega_w(\hat{e}_y\sin(k_wz))}{\gamma_e\Omega_0})}(1-\frac{\Omega_1k_{0+}\Omega_w(\hat{e}_y\sin(k_wz))}{\gamma_e\Omega_t\Omega_0k_1(1-\frac{\Omega_w(\hat{e}_y\sin(k_wz))}{\gamma_e\Omega_t})}) \tag{36}$$

Using Eqs.(35) and (36) and computing relativistic factor γ_e, it is achieved[37],

$$\frac{d^2\mathbf{E}_{t+}}{dz^2}+[\frac{\Omega_t^2}{c^2}(1-\frac{\Omega_p^2}{\Omega_t^2(1-\frac{\Omega_w(\hat{e}_y\sin(k_wz))}{\Omega_t})(1+\frac{\Omega_w(\hat{e}_y\sin(k_wz))}{\Omega_t})})+\alpha_t]\mathbf{E}_{t+}=$$
$$[\frac{\Omega_p^2\Omega_t\mu^{*}}{2c^2\Omega_0(1-\frac{\Omega_w(\hat{e}_y\sin(k_wz))}{\Omega_0})}(1-\frac{\Omega_1k_{0+}\Omega_w(\hat{e}_y\sin(k_wz))}{\Omega_t\Omega_0k_1(\frac{\Omega_w(\hat{e}_y\sin(k_wz))}{\Omega_t}-1)})+\alpha_{tt+}]\mathbf{E}_{0+} \tag{37}$$

In the above equation α_{t+} and α_{tt+} are relativistic increasing mass. Physically, when α_{t+} and α_{tt+} are vanished, the effect of non-relativistic appears. Furthermore, employing Eq.(31), we can obtain THz radiation generation intensity. It should be better to mention also that with respect to Eq.(24) f_+ is the function of z.

4. Numerical discussions

In this section, a numerical study has been presented to study the relativistic effects of the wiggler field on the terahertz radiation generated by intense laser beam interacting with collisionless magnetoplasma which propagates through a planar magnetostatic wiggler. It's proposed a Nd:YaG laser with frequency $\Omega_0 = 1.88\times10^{15} Hz$, intensity $I \approx 10^{13} W/m^2$, normalized ripple density amplitude µ=0.4, and the beam waist $r_0 = 15\times10^{-6} m$. In the meantime, plasma frequency considered as a function of physical parameter $\Omega_p = 0.1\Omega_0$. In addition, initial boundary conditions in z=0 are $f_+ = 1,\ \partial f_+/\partial z = 0$.

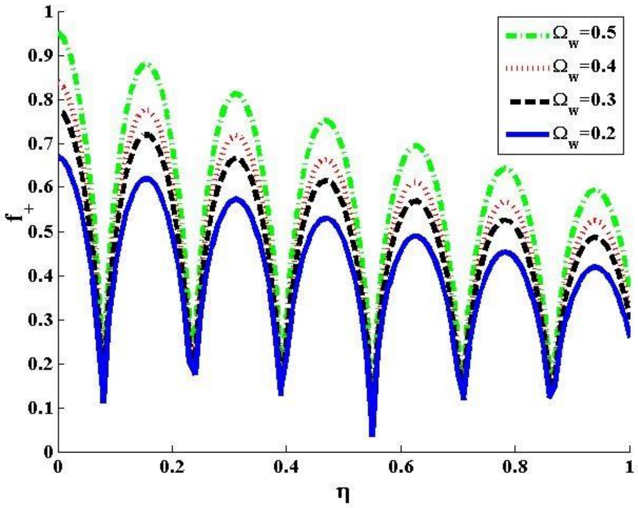

Fig. 1. Variations of beam width parameter f_+ with respect to variations of normalized distance ($\eta = z/k_{0+} x_0^2$) with different wiggler frequencies (Ω_w =0.2,0.3,0.4,0.5).

Fig. 1 demonstrates variations of beam width parameter f_+ with respect to variations of normalized distance ($\eta = z/k_{0+} x_0^2$) with different wiggler frequencies Ω_w =0.2,0.3,0.4 and 0.5 in the presence of a planar magnetostatic wiggler. As shown from this figure, by increasing the normalized distance, the beam width parameter of laser beam has oscillating trend. Furthermore, it can be seen that increasing of wiggler magnetic field leads to decreases of beam width parameter. In fact, when we employ the magnetic wiggler field, self-focusing in magnetoplasma improve, appropriately. Moreover, it is found that by employing wiggler magnetic field, maximum spot-size of the laser beam reduces as a result of laser beam propagating in magnetoplasma.

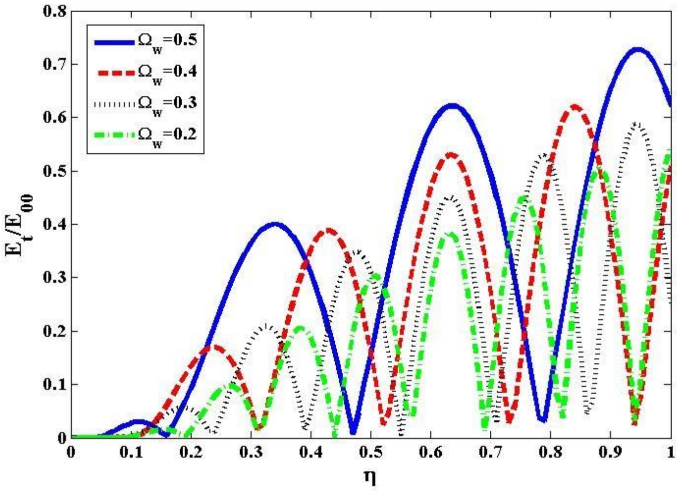

Fig.2. Variations of normalized THz field amplitude (E_t/E_{00}) with respect to variations of normalized distance ($\eta = z/k_{0+} x_0^2$) with different wiggler frequencies (Ω_w=0.2,0.3,0.4,0.5).

Fig. 2 shows variations of normalized THz field amplitude (E_t/E_{00}) with respect to variations of normalized distance ($\eta = z/k_{0+} x_0^2$) with different wiggler frequencies Ω_w=0.2,0.3,0.4, and, 0.5. As can be seen in Fig. 2 the maximum value of THz conversion efficiency is 50%, 60%, 65% and 75% for different wiggler frequencies Ω_w=0.2,0.3,0.4, and, 0.5 respectively. Furthermore, it is observed that conversion efficiency is fixed when laser beam is de-focused in ($f_+ = 1$). Besides, it is found that the THz conversion efficiency significantly enhanced with increasing of the wiggler field strength. As a matter of fact, that self-focusing of the laser beam and wiggler magnetic field play crucial roles in process of conversion efficiency. It should be better to mention that self-focusing of the laser beam yields to increasing of laser intensity and consequently with this enhancement, conversion efficiency is increased.

5. Conclusions

In this work, terahertz (THz) radiation generated by coupling of intense laser beam and rippled density plasma with collisionless magnetoplasma in the presence of a planar magnetostatic wiggler is studied. Analytical formulation governing the laser spot-size with respect to competition between diffraction and self-focusing terms of laser beam has been obtained. Furthermore, the effects of the wiggler field on the variations of beam width parameter and THz field amplitude has been considered. It was found that increasing of wiggler magnetic field leads to reduces of beam width parameter. As a matter of fact, when we employ the magnetic wiggler field, self-focusing in magnetoplasma improve, properly. Moreover, it was concluded that by employing wiggler magnetic field, maximum spot-size of the laser beam decreases as a result of laser beam propagating in magnetoplasma. As well, it was seen that the THz conversion efficiency significantly enhanced, with increasing of the wiggler field strength. Besides, it was found that self-focusing of the laser beams and wiggler magnetic fields are important factors in mechanism of conversion efficiency.

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