

Numerical analysis of nonlinear current density for generating THz-wave by chirped pulses beating in plasmas

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Abstract

In this model, effect of frequency chirp lasers on nonlinear current density in rippled-density plasma is investigated. Our numerical simulations reveal that the variation of frequency chirp parameter and ripple amplitude has a significant role to enhance nonlinear oscillating current.

Keywords: *Nonlinear current density, Terahertz wave, rippled density plasma, frequency chirp parameter.*

Introduction:

To understand the concept of origin of terahertz field due to beating of laser-pulses in a nonlinear medium, such as plasmas, we provide a theoretical model below. In the present short communication, we have re-examined the above scheme and included the influence of density ripple in order to enhance the THz intensity. The density ripple is applied on the chirped laser pulses in order to adjust and control the yield of the THz wave. The density ripple produces current and density perturbations and plays a vital role in establishing the phase-matching condition. Due to this, resonance condition is achieved. THz amplitude enhances considerably because of density-ripple. Mehta *et al.* [1-2] has investigated the outcome of frequency chirp pulses for THz generation in magnetized plasmas. The interaction duration can be improved by using suitable value of frequency-chirp and applied magnetic field further imparts a significant momentum to THz photon [3-4]. Also a method to generate THz by lasers beating in collision-less, hot-plasmas with density rippled has been investigated [5], and concluded that the emitted power of THz is proportional to the square of the amplitude of ripples.

Observations for numerical calculation:

We assume an incident pulse having a linear chirp (frequency) in positive direction symbolize as; $\Omega_1 = \omega_0(1 - b\omega_0(z/c - t))$, where the incident pulse frequency, ω_0 is in the absence of chirp parameter (b). Two pulses having slightly different frequencies propagate through the plasma, whose frequencies can be chosen as the difference, $\Omega = \Omega_1 - \Omega_2$, will be

in THz region. Lasers' electric field inside the plasma is; $\vec{E}_j = \hat{y}A_j e^{-i(\Omega_j t - K_j z)}$, where, $j=1,2$. Under the influence of a force (ponderomotive) arises due to electrons' oscillatory velocity, the oscillations of these electrons attain a nonlinear motion, results the generation of nonlinear perturbations in plasma density. As an outcome, some space-charge-field is developed, results a linear perturbations in density. Both the perturbations contribute to a linear force. Therefore, total velocity of the electrons due to the linear and nonlinear force can be calculated as, $\vec{v}_\Omega^{NL} = F_{pz} (\Omega_c (1 + \chi_e) \hat{x} - i\Omega_c \hat{z}) / m(\Omega^2 - \Omega_c^2)(1 + \chi_e)$. Thus the nonlinear current density can be obtained using the following equation: $\vec{J}_\Omega^{NL} = -en\vec{v}_\Omega^{NL} / 2$.

Results & Discussion:

We have introduced ripple-density in plasma such as, $n = n_0 + n_{q0} e^{iqz}$. To generate a nonlinear current-density at Ω, \vec{K} , this \vec{v}_Ω^{NL} at $(\Omega, \vec{K}_1 - \vec{K}_2)$ beats through density-ripple. Here $\vec{K} = \vec{K}_1 - \vec{K}_2 + \vec{q}$, is responsible for THz emission. An additional momentum is provided by the density-ripple wave number q, in the z-direction to attain the resonance state. It should be noted that highest energy-transfer takes place for this state thus the density-ripples in plasmas should be periodic for strong THz generation. Finally, for an optimum value of chirp and pulse intensity a notable gain in THz yield has been obtained.

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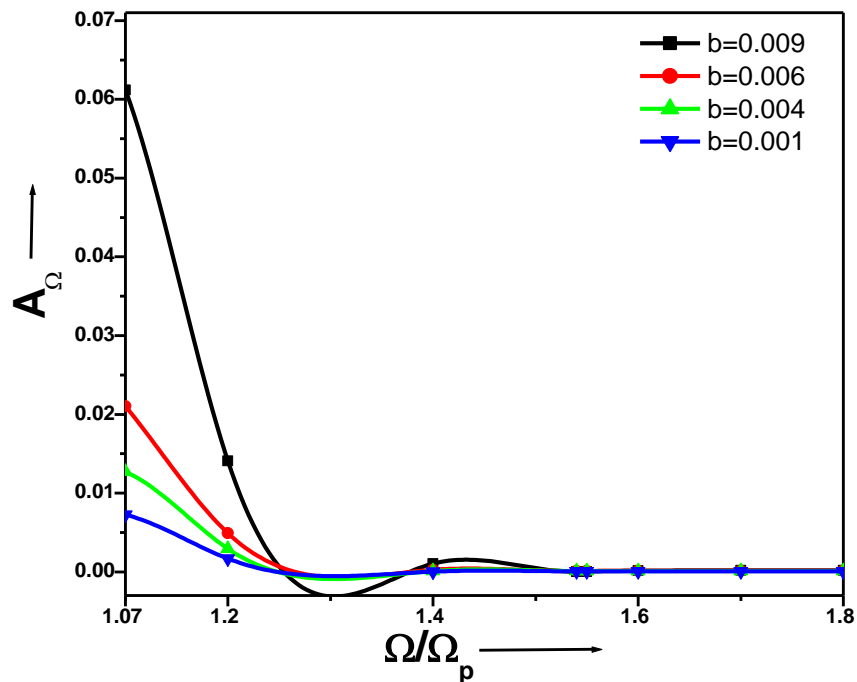


Fig.1. Plot for the variation of normalized amplitude of THz A_Ω versus normalized THz frequency Ω/Ω_p for 30% ripple.