THINK INDIA JOURNAL

ISSN:0971-1260
Vol-22-Issue-37-December -2019

Resonantly enhanced II-harmonic amplitude and pulse slippage in plasma under density ripple

Jyoti Rajput, Alka Mehta and Niti Kant*
Department of Physics, School of Chemical Engineering and Physical Sciences, Lovely Professional University, Phagwara, Punjab, India.

**Email: nitikant@yahoo.com*

Abstract

Second harmonic wave generation in plasma under the influence of density ripple has been observed analytically. A Laser having frequency Ω_1 *with wave vector* K_1 *is traversing in plasma with density ripple (*$0, \vec{K}_0$*), hence generating current* $d_0\vec{v}_1$ *and density perturbations at* $(\Omega_1, \vec{K}_1 + \vec{K}_0)$*. The inclusion of density ripple is required in order to resonantly enhance harmonic generation phenomenon. Due to increase in density ripple, second harmonic generation amplitude is enhanced.*

1. Introduction:

For so many decades, laser plasma based phenomenon such as harmonic generation, electron acceleration and terahertz radiation is a matter of great interest [1-11]. If we talk about harmonics, the emphasis has been put forth on the second (II) [12] and third (III) harmonics [13] mainly. One can note that the production of the second harmonic is prominent close to the critical layer due to two methods, initially; the propagation of a p-polarized light with respect to the density gradient endures the conversion of a linear mode into a Langmuir wave. Due to this, the density oscillations are produced by beating of oscillatory velocity due to the ponderomotive force of laser and a second harmonic current is emerged leads to second harmonic radiation. Secondly; decay instability is experienced due to laser passing into a Langmuir wave, thereby creating an ion acoustic wave close to critical layer. A down shifted second harmonic wave is excited due to the Langmuir wave beating with the laser. This process is significant only if an additional momentum $\hbar\vec{K}_2 - 2\hbar\vec{K}_1$ is obtainable per photon in the system. Parasher and Pandey [14] have projected efficient II-harmonic generation by imparting a density ripple in the contact region. Rajput *et al.* [13] have inspected the pulse

 Copyright ⓒ 2019Authors

ISSN:0971-1260
Vol-22-Issue-37-December -2019

slippage for resonant III-harmonic generation in plasma due to external wiggler. Here, in this communication, the density ripple serves a vital role in obtaining the resonance condition. We have calculated the equations for II-harmonic amplitude in the influence of density ripple. We study the resonant II- harmonic generation of a short pulse laser in plasma embed with density ripple. The slippage of the II-harmonic pulse is observed as it has a higher group velocity than the pump pulse. Also we study the effect of increase in density ripple in resonant II harmonic generation. Higher the value of density ripple, higher the amplitude and intensity of second harmonic pulse.

We observe the current density with discussion including effect of density ripple.

2. Non linear current density analysis and discussion

An electromagnetic wave $\vec{E}_x = \hat{x}A_1 \, e^{[-i(\Omega_1 t - K_1 z)]}$ is taken in an un-magnetized plasma, d_0^0 is the average electron density. The plasma encloses a density ripple $d_0^0 = d_0 \, e^{(i\vec{K}_0 \cdot \vec{x})}$, whose wave vector $\vec{K}_0$ makes an angle ϕ with z axis. In response to the field of the electromagnetic wave, the electrons acquire an oscillatory velocity; $\vec{v}_1 = v_1 e^{-i(\Omega_1 t - \vec{K}_1 z)}$**.** Due to density ripple, current density $\vec{J}_2$ can be written as $\vec{J}_2^{NL} = -ed_0 v_1^2 / 4\Omega_1 (\hat{x} K_{0x} + \hat{z} K_1 / 2)$. Now, using Poisson equation, we obtain the second harmonic density perturbation d_2. On solving the wave equation, We get, $\partial A_2 / \partial z + (1/v_{g2}) \partial A_2 / \partial t = \alpha_2 \left[F(z - v_{g1} t) \right]^2$ where, $\alpha_2 = -e\Omega_p^2 / 8mc^2 K_2 \Omega_1^2 (2K_{0x} + K_1)$. Furthermore, this equation can be depicted as

$\beta \partial A_2 / \partial \xi + \partial A_2 / \partial d = \alpha_2 A_0^2 e^{(-\xi^2 / \xi_0^2)}$,where $\beta = (1 - v_{g1} / v_{g2})$, $\xi_0 = \tau \, v_{g1}$.

Finally we calculated the ratio of II-harmonic and fundamental amplitudes as:

$$\left| \frac{A_2}{A_0} \right| = \left| \frac{\alpha_2 A_0 \xi \sqrt{\pi}}{2\beta} \left[Erf(z' - t) + Erf\left\{ (\beta - 1) z' - t \right\} \right] \right|$$

Here, d_0 / d_0^0 is taken as a constant for which various values are taken with other optimized parameters in our graphs under density ripple for investigation of intensity and amplitude of second harmonic pulse. We have observed the plot $\left| A_2 / A_0 \right|$ with $z' = z / \xi_0$ for normalized density ripple d_0 / d_o^0 =1, 2 and 3 for $\Omega_p^2 / \Omega_1^2 = 0.38$ at time t' = 6. With the enhancement in density ripple, we observe a significant resonant increase in the second harmonic amplitude.

 Copyright ⓒ 2019Authors

ISSN:0971-1260
Vol-22-Issue-37-December -2019

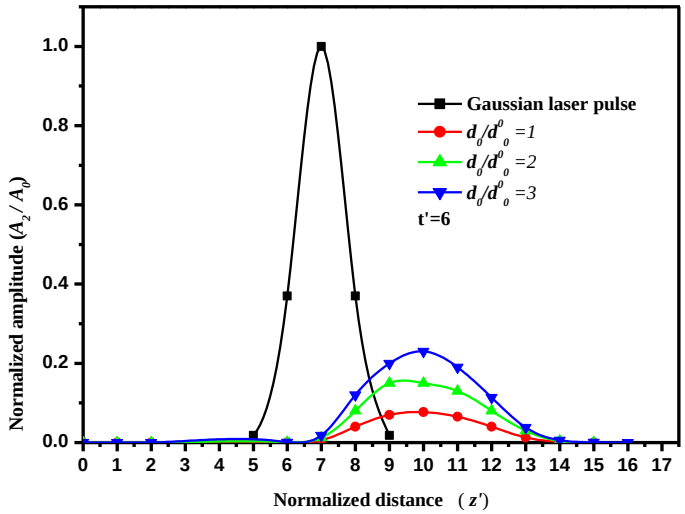


Figure: Graph of $|A_2/A_0|$ with $z' = z/\xi_0$ for normalized density ripple d_0/d_o^0=1, 2 and 3 for $\Omega_p^2/\Omega_1^2 = 0.38$ at time $t' = 6$.

References:

[1] G. S. Kino and J. H. Krenz, "Parametric oscillation and harmonic generation in a plasma discharge," Appl. Phy. Lett. Vol.3, pp.53, Aug. (1963).

[2] M. S. Sodha and P. K. Kaw, Non- linear generation of combined frequencies in a plasma, Proc. Phys. Soc. Vol. 88(2), pp. 373, Nov. (1966).

[3] N. Kant, J. Rajput, P. Giri and A. Singh, "Effect of axial magnetic field on axicon laser-induced electron acceleration," High En. Den. Phys. Vol. 18, pp.20-25, Mar. (2016).

[4] J. Rajput, N. Kant and A. Singh, "Electron energy enhancement by frequency chirped axicon Gaussian laser pulse in vacuum," AIP Conference Proceedings, Vol. 1860, pp. 020005, Jul. (2017).

[5] A. Singh, J. Rajput and N. Kant, "Combined influence of azimuthal and axial magnetic fields on resonant electron acceleration in plasma," Laser Phys., Vol. 27, pp. 110001, Oct. (2017).

[6] N. Kant, J. Rajput and A. Singh, "Electron acceleration from rest to GeV energy by chirped axicon Gaussian laser pulse in vacuum in the presence of wiggler magnetic field," High En. Den. Phys. Vol., pp. 26 16-22, Mar. (2018).

[7] J. Rajput, N. Kant and A. Singh, "Electron acceleration due to a circularly polarized laser pulse on a downward plasma density ramp in the presence of an azimuthal magnetic field," AIP conference Proceedings, Vol. 2006, pp. 030025, Aug. (2018).

Copyright ⓒ 2019Authors

ISSN:0971-1260
Vol-22-Issue-37-December -2019

[8] A. Singh, J. Rajput and N. Kant, "Magnetic field assisted enhanced electron acceleration due to a chirped echelon phase modulated laser in vacuum," Optik, Vol. 182, pp. 858-865, April (2019).

[9] A. Mehta J. Rajput and N. Kant, "Effect of frequency-chirped laser pulses on terahertz radiation generation in magnetized plasma," Laser Physics, Vol. 29 (9), pp. 095405, Aug. (2019).

[10] J. Rajput, N. Kant and A. Singh, "Resonance assisted enhanced electron acceleration in the presence of self-generated magnetic fields due to circularly polarized laser in plasma," AIP Conference Proceedings, Vol. 2136 (1), pp. 060012, Aug. (2019).

[11] A. Mehta, N. Kant and S. Vij, "Generation of terahertz (THz) radiation by p-polarised laser s beating in hot plasma with surface density ripple," Laser Phys. Letts. Vol. 16(4), pp. 045403, Feb. (2019).

[12] Nitikant and A. K. Sharma, "Effect of pulse slippage on resonant second harmonic generation of a short pulse laser in a plasma," J. Phys. D: Appl. Phys., Vol. 37, pp. 2395-2398, Aug. (2004)

[13] J. Rajput, N. Kant, H. Singh and V. Nanda, "Resonant third harmonic generation in a short pulse laser in plasma by applying a wiggler magnetic field," Opt. Commun. Vol.282, pp. 4614-4617, Dec. (2009)

[14] J. Parashar and H. D. Pandey, "Second-harmonic generation of laser radiation in a plasma with a density ripple," IEEE Trans. Plasma. Sci, Vol. **20**, pp. 6, Dec. (1992)

 Copyright ⓒ 2019Authors