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DIFFUSION-INDUCED MODULATIONAL INSTABILITY IN SEMICONDUCTOR QUANTUM PLASMA WITH STRAIN DEPENDENT DIELECTRIC CONSTANT

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ABSTRACT

In the present paper we report the diffusion-induced modulational instability (MI) of an intense laser beam in materials ($BaTiO_3$) with high dielectric constant using quantum hydrodynamic model of plasmas including Bohm potential and Fermi degenerate pressure. For the study of modulation interaction, we have considered that the origin of this nonlinear interaction lies in the third order nonlinear electrical susceptibility arising due to diffusion-induced nonlinear current density and strain dependent polarization of the medium. We have studied the qualitative behavior of parametric dispersion, gain profile and threshold value of pump field with respect to different parameters. It is found that due to the quantum effect the growth rate of MI in the limited range of parameters increases and required threshold amplitude of wave reduces. Hence the result of this analysis would be useful in designing acousto-electric modulators.

KEYWORDS: Quantum Plasma, Modulational Instability, Strain dependent dielectric constant.

I. INTRODUCTION

In recent years, there has been considerable interest in global properties of semiconductor quantum plasma. Before delving into the peculiarities of quantum plasmas, it is necessary to understand what is meant by this term. Indeed, all plasmas are in some sense quantum, as they consist of charged particles that obey the laws of quantum mechanics. However, as the density of classical plasma increases, or its temperature decreases, it can enter a regime when the quantum nature of its constituent particles starts to affect its macroscopic properties and dynamics. Quite naturally, such plasmas are called quantum plasma [1]. The simplest example where both plasma and quantum mechanical effect coexist is the free electron gas in a metal. During the past few years there has been a great interest in the study of quantum effects in plasma in view of its potential utility found in laser plasma interaction [2], and in ultra small electronic devices[3] and in metal nanostructures [4].

The nonlinear interaction between matter and wave in plasmas is one of the most important subjects of plasma physics. Nonlinear plasma physics is an area of extensive research because of its attached technological interest. Plasma nonlinear effects are often used to illustrate general nonlinear phenomenon in arbitrary media. Modulation interaction is one of the most basic nonlinear phenomenon in plasma physics. Such interactions describe various modulational effects in nonlinear media, such as frequency modulation, amplitude modulation, phase modulation, self modulation etc. Modulation instability (MI) is one of the most ubiquitous types of instabilities associated with wave propagation in plasmas and plays a key role in the development of many nonlinear plasma processes.

MI is a universal phenomenon that exists in many nonlinear systems such as fluids, plasma, nonlinear optics, discrete nonlinear systems, such as molecular chains and Fermi-resonant interfaces and waveguide arrays [5-8], etc. The phenomenon of MI is of great interest both for the general theory of nonlinear waves and for its applications. MI exists due the interplay between the nonlinearity and dispersion or diffraction. It was first observed by Benjamin and Feir [9] for waves on deep water and by Bespalov and Talanov [10] for EM (electromagnetic) waves in nonlinear media. In its simplest version, the modulation instability phenomenon consists in the instability of nonlinear plane waves against weak long-scale modulations with frequencies lower than some critical value. Long time evolution leads to the growth of side bands and a periodic exchange of energy between a pump and sidebands during the wave propagation. In modern nonlinear optics MI is considered as a basic process that classifies the qualitative behavior of modulated waves (envelope waves) and may initialize the formation of stable entities such as envelop solitons [11].

In this context, MI is a passive nonlinear effect due to its potential utility in ultrafast technologies. Recent progress in micro- structured optical fibers offers new opportunities for the control of dispersive properties and thus, to new potential applications of MI across a broad spectral range. Qualitative analysis of the modulation instability is important for design and optimization of fiber lasers and amplifiers in which the wave intensity grows up exponentially and MI dramatically intensifies nonlinear instabilities. As a nonlinear fiber effect is sensitive to dispersion, MI is also very attractive for various measurement techniques [12-13]. A wide range of literature is available on the investigation of modulation interactions in semiconductor plasma (with and without quantum effect) [14-20]. However, in all these studies any condensed treatments based on the nonlinear effects such as diffusion of the excitation density that is responsible for the nonlinear refractive index change in quantum plasmas with SDDC (Strain dependent dielectric constant) effect has been normally ignored.

Motivated by the present status, in this paper authors aim to highlight some of the modifications occurred in MI in diffusive semiconductor plasma with SDDC due to quantum effect through Bohm potential. The purpose of the work is to produce a quantum counterpart starting with the quantum hydrodynamic model (QHD) of charged particle system proclaimed by Manfredi and Hass [21]. To do this, we consider some of the well-known concepts and phenomena familiar to all plasma physicists to see how they change, often qualitatively in quantum plasma as compared to their counterparts in classical plasma. Our purpose in this paper is to investigate the modulational instability in a semiconductor material with high dielectric constant. We assumed that it is due to a parametric four-wave mixing process involving the incident pump, the upper and lower side band signals and induced acousto-electric idler wave characterized by the cubic nonlinear susceptibility. To our knowledge, no systematic study has yet been performed to investigate the effect of strain-induced deformations (depending on the nature of the medium) on the modulational interaction of electromagnetic waves in diffusive semiconductor quantum plasma. The strain dependence of the optical susceptibility of a semiconductor results in an additional acousto-electric interaction in the presence of a static electric field, which may even be stronger than piezoelectric. In the present article, the third order susceptibility due to nonlinear induced current density, threshold pump amplitude required to incite the modulational amplification and the growth rate of modulated wave in quantum plasma are derived and studied them to investigate the effect of parameters of high dielectrics. We found the acoustoelectrical modulational amplification of the laser beam to be higher in diffusive semiconductor materials with high dielectric constant with quantum effects compared to those found in other media.

II. THEORETICAL FORMULATION

In this section, we deal with theoretical formulation of the modulation interaction in n-type diffusive semiconductor plasma having SDDC arising due to third order susceptibility using QHD model. In order to determine the third-order susceptibility, we consider that a spatially uniform pump electric field $E_0 \exp[i(k_0 x - \omega_0 t)]$ is applied along the positive x direction. We proceed with the zero order and first order electron momentum transfer equations of the QHD model given as

$$\frac{\partial V_0}{\partial t} + \nu V_0 = \frac{e}{m} E_0 . \tag{1}$$

$$\frac{\partial V_1}{\partial t} + \nu V_1 + \left(V_0 \frac{\partial}{\partial x}\right) V_1 = \frac{e}{m} E_1 - \frac{1}{m n_0}\frac{\partial P_f}{\partial x} + \frac{\hbar^2}{4m^2 n_0}\frac{\partial^2 n_1}{\partial x^2}, \tag{2}$$

Where V_0 and V_1 are the zeroth and first order oscillatory fluid velocities of an electron of effective mass m and charge e. ν is the phenomenological electron collision frequency.

In above equation P_f is Fermi pressure given as

$$P_f = {mV_f^2 n_1^3}\Big/{3n_0^2}, \tag{3}$$

with $V_f = {2K_B T_f}/{m}$ is the Fermi speed in which K_B is the Boltzmann constant and T_f is the Fermi temperature of electrons. Pressure is interpreted as an outcome of velocity dispersion around the mean velocity of the fluid. Therefore, equation (3) can be stated as equation of state to a one dimensional zero temperature Fermi gas. Our analysis is based on the QHD model which includes two different quantum effects: (i) quantum diffraction due to quantum correlation of density fluctuations that is taken into account by the term proportional to the $\hbar^2$ in equation (2), where $\hbar$ is the Planks constant divided by 2π, (ii) quantum statistics is included in the model through the equation of state [Eq. (3)] which takes into account the Fermionic character of the plasma particles [22]. These contributions may be interpreted alternatively as quantum pressure terms or as quantum Bohm potentials. In other applications in semiconductor physics, the Bohm potential is responsible for tunneling and differential resistance effects. Quantum mechanical effects become important when the inter-electron distance is of the order of the thermal de Broglie wavelength and the temperature is lower than the Fermi temperature. Here the overlapping of electron wave functions occurs Heisenberg's uncertainty and Pauli's exclusion principles. Here the contribution of hole on quantum diffraction effect can be neglected because the effective mass of a hole is more than the effective mass of an electron and therefore the drift velocity of a hole is less than the drift velocity of electron.

To meet out the aim of this article i.e. for the derivation of third order susceptibility authors have used the one dimensional continuity and Poisson's equations those are given below

$$\frac{\partial n_1}{\partial t}+V_0\frac{\partial n_1}{\partial x}+n_0\frac{\partial V_1}{\partial x}+D\frac{\partial^2 n_1}{\partial x^2}=0, \tag{4}$$

$$\frac{\partial E_1}{\partial x}=\frac{en_1}{\varepsilon}+\frac{(\varepsilon g E_0)}{\varepsilon}\frac{\partial^2 u^*}{\partial x^2}, \tag{5}$$

Here $D=\frac{K_B T_f}{e}\mu$ is the diffusion coefficient with $\mu=\frac{e}{m\nu}$ is the electron mobility. In equation (4) n_0 and n_1 are the equilibrium and perturbed carrier concentrations, respectively. In equation (5) ε and g are the scalar dielectric and coupling constants, respectively. In modulation process pump beam generates an acoustic perturbation due to the lattice vibrations at the phonon mode frequencies within the semiconductor medium. The lattice vibrations lead to an electron-density perturbation which couples nonlinearly with the pump wave and drives the acoustic waves at modulated frequencies. The equation of motion of the acoustic wave in a centrosymmetric medium is given by

$$\rho\frac{\partial^2 u}{\partial t^2}=C\frac{\partial^2 u}{\partial x^2}-(\varepsilon g E_0)\frac{\partial E_1^{\ *}}{\partial x}, \tag{6}$$

Where u is the lattice displacement, ρ is the mass density of the crystal, C the elastic constant.

In the multimode theory of MI process, the influence of a strong pump beam generates a carrier density perturbation, which is associated with phonon-mode and varies with the acoustic frequency. The equation for density fluctuation of the coupled electron-plasma wave in a n-type diffusive semiconductor quantum plasma, is obtained by using equations (4) and (5) as

$$\frac{\partial^2 n_1}{\partial t^2}+\nu\frac{\partial n_1}{\partial t}+\nu D\frac{\partial^2 n_1}{\partial x^2}+n_1\overline{\omega}_p^2+\frac{n_0 e(\varepsilon g E_0)}{m\varepsilon}\frac{\partial^2 u^*}{\partial x^2}=-ikn_1\overline{E}, \tag{7}$$

Here $\overline{\omega}_p^2=\omega_p^2+k^2 V_f^{'2}$ being the plasma frequency modified by the quantum correction term $V_f^{'}=V_f\left(\sqrt{1+\Gamma_e}\right)$ with $\Gamma_e=\frac{\hbar^2 k^2}{8mk_B T_f}$, $\omega_p=\sqrt{\frac{n_0 e^2}{m\varepsilon}}$ is the plasma frequency and $\overline{E}=\frac{eE_0}{m}$.

The pump beam thus oscillates at the density perturbation to produce forced wave disturbances at $(\omega_a+\omega_0)$ the upper (anti-Stokes) and $(\omega_a-\omega_0)$ the lower (Stokes wave) sideband frequencies [23]. In the present work the higher order scattering terms, being off resonance can be filtered out and we are left with first order resonant sideband frequencies $(\omega_a\pm\omega_0)$ by assuming a long interaction path [14]. Thus the density perturbations oscillating at these side band frequencies can be expressed after simplification as

$$n_1(\omega_\pm,k_\times)=\frac{iek_\pm^3 n_0\varepsilon^2 g^2|E_0|^2 E_1}{m\rho\varepsilon(\omega_a^2-k_a^2V_a^2)}\left[\overline{\omega}_p^2-\omega_\pm^2-i\nu\omega_\pm-\nu Dk_\pm^2+ik_\pm\overline{E}\right]^{-1}, \tag{8}$$

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Here $\omega_+ = \omega_a + \omega_0$ and $\omega_- = \omega_a - \omega_0$. In the analytical study of modulation process, we have neglected the effect of the transition dipole moment with the view to study the contribution of nonlinear current density due to diffusion of the charge carrier only. The diffusion induced nonlinear current density for the upper and lower sidebands, respectively can be represented by

$$J_d(\omega_+, k_+) = -eD\frac{\partial n_1(\omega_+, k_+)}{\partial x}, \tag{9a}$$

$$J_d(\omega_-, k_-) = -eD\frac{\partial n_1(\omega_-, k_-)}{\partial x}. \tag{9b}$$

The induced cubic nonlinear electric polarization being the time integral of the nonlinear current density $J_d(\omega_\pm, k_\pm)$ at the modulated frequency, may be expressed as

$$P_d(\omega_\pm, k_\pm) = \int J_d(\omega_\pm, k_\pm)dt. \tag{10}$$

Thus diffusion-induced polarization has contribution from both upper and lower side bands and can be represented as

$$P_d(\omega_\pm, k_\pm) = P_d(\omega_+, \omega_+) + P_d(\omega_-, \omega_-). \tag{11}$$

Thus from equations (8) to (11), the total effective third order diffusion induced polarization becomes

$$P_d(\omega_\pm, k_\pm) = \frac{-2\varepsilon^2 g^2 k^4 k_B T_f \omega_p^2 |E_0|^2 E_1}{\rho m(\omega_a^2 - k_a^2 V_a^2)}\left[\frac{(\Delta^2 - k^2\bar{E}^2 + \omega_0^2 \nu^2) - 2ik\bar{E}\Delta}{(\Delta^2 - k^2\bar{E}^2 + \omega_0^2\nu^2)^2 - 4k^2\bar{E}^2\Delta^2}\right], \tag{12}$$

Where $\Delta = \bar{\omega}_p^2 - \omega_0^2 - \nu D k^2$.

The induced polarization due to cubic nonlinearities at modulated frequencies $(\omega_\pm, k_\pm)$ is defined as,

$$P_d(\omega_\pm, k_\pm) = \varepsilon_0 \chi^{(3)} |E_0|^2 E_1. \tag{13}$$

Due to the carrier diffusion, in four-wave parametric process induced effective nonlinear susceptibility of the third order can be obtained using equations (12) in (13) as

$$\chi^{(3)} = \frac{-2\varepsilon^2 g^2 k^4 k_B T_f \omega_p^2}{\varepsilon_0 \rho m(\omega_a^2 - k_a^2 V_a^2)}\left[\frac{(\Delta^2 - k^2\bar{E}^2 + \omega_0^2\nu^2) - 2ik\bar{E}\Delta}{(\Delta^2 - k^2\bar{E}^2 + \omega_0^2\nu^2)^2 - 4k^2\bar{E}^2\Delta^2}\right]. \tag{14}$$

Equation (14) characterizes the steady-state optical response of the medium and governs the nonlinear wave propagation through the medium due to diffusion of the charge carrier. Hence, the process may be termed as diffusion-induced modulation interaction. It is evident from the above expression that $\chi^{(3)}$ is found to be influence by the quantum and SDDC effects and also depends upon material parameter, such as equilibrium carrier concentration n_0 via the plasma frequency ω_p. After rationalization of equation (14), one can easily obtain real and imaginary parts of effective nonlinear susceptibility for nondispersive acoustic mode as

$$[\chi_{real}^{(3)}] = \frac{-2\varepsilon^2 g^2 k^4 k_B T_f \omega_p^2}{\varepsilon_0 \rho m(\omega_a^2 - k_a^2 V_a^2)}\left[\frac{(\Delta^2 - k^2\bar{E}^2 + \omega_0^2\nu^2)}{(\Delta^2 - k^2\bar{E}^2 + \omega_0^2\nu^2)^2 - 4k^2\bar{E}^2\Delta^2}\right], \tag{15a}$$

$$[\chi_{img}^{(3)}] = \frac{4\varepsilon^2 g^2 k^5 k_B T_f \omega_p^2}{\varepsilon_0 \rho m(\omega_a^2 - k_a^2 V_a^2)}\left[\frac{\bar{E}\Delta}{(\Delta^2 - k^2\bar{E}^2 + \omega_0^2\nu^2)^2 - 4k^2\bar{E}^2\Delta^2}\right]. \tag{15b}$$

The real part of $\chi^{(3)}$ displays the dispersive characteristics of the modulated wave, whereas the imaginary part of $\chi^{(3)}$ can be used to obtain the gain. It can be observed from equation (15a) that there is an intensity dependent refractive index via $[\chi_{real}^{(3)}]$ leading to the possibility of a focusing or defocusing of the propagating

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beam. On order to search the possibility of modulation amplification in a semiconductor medium, we employ the relation

$$\alpha = -\frac{k}{2\varepsilon}\left[\chi_{img}^{(3)}\right]|E_0|^2, \qquad (16)$$

Here, α is the effective nonlinear absorption coefficient. The nonlinear steady state growth of the modulated signal (g_s) is possible only if α obtainable from equation (16) is negative. Thus the growth rate of the modulated beam for pump amplitudes well above the threshold electric field can obtained from the equations (15b) and (16) as

$$g_s = -\frac{2\varepsilon g^2 k^6 k_B T_f \omega_p^2 \bar{E}|E_0|^2}{\varepsilon_0 \rho m(\omega_a^2 - k_a^2 V_a^2)}\left[\frac{\Delta}{(\Delta^2 - k^2\bar{E}^2 + \omega_0^2 \nu^2)^2 - 4k^2\bar{E}^2\Delta^2}\right]. \qquad (17)$$

The necessary threshold value of the pump amplitude required for the onset of the MI is given by

$$E_{0th} = \frac{m}{ek}\left[\Delta^2 + \omega_0^2 \nu^2\right]^{1/2}. \qquad (18)$$

The above equation describes that the threshold value is affected by the quantum correction term through $\Delta = (\varpi_p^2 - \omega_0^2 - \nu Dk)^2$.

III. RESULTS AND DISCUSSION

The In For analytical investigation of the modulation interaction processes we consider the irradiation of semiconductor sample $BaTiO_3$ by CO_2 laser at 77K. The following material parameters are taken as representative values to establish the theoretical formulation:

$m = 0.0145 m_0$, $\varepsilon_s = 2000$, $V_a = 3\times10^3 ms^{-1}$

$\nu = 5\times10^{11} s^{-1}$, $\omega_0 = 1.78\times10^{14} \sec^{-1}$ $\omega_a = 2\times10^{12}\sec^{-1}$, $\rho = 4\times10^3 kgm^{-3}$ $T = 77k$

Using the above parameters the results of our calculations are depicted in the form of curves in the figures 1-5.

1. Threshold characteristics

Figure 1 shows the dependence of threshold (with and without quantum effect) on wave number k. It is seen that the threshold field [which is inversely proportional to the wave vector k evident from eq. (18)] decreases with increase in magnitude of wave vector k in absence of quantum correction term. Figure shows that the threshold electric field (in presence of quantum effect) decreases with increase in wave vector when $\varpi_p^2 < \omega_0^2$.

The threshold electric field attains its minimum value $E_{0th} = 1.239\times10^6 Vm^{-1}$ at $k = 2\times10^8 m^{-1}$, when $\varpi_p^2 \approx \omega_0^2$ condition is achieved. Further if we increase wave vector beyond this critical value, the threshold required for the onset of modulational amplification increases. This sharp fall and rise in the characteristics of the threshold electric field may be attributed to the resonance between ϖ_p and ω_0 in presence of quantum correction term $\Delta = (\varpi_p^2 - \omega_0^2 - \nu Dk)^2$ through $\varpi_p^2 = \omega_p^2 + k^2 V_f'^2$. It may be observed from this figure that the presence of quantum correction term reduces threshold electric field.

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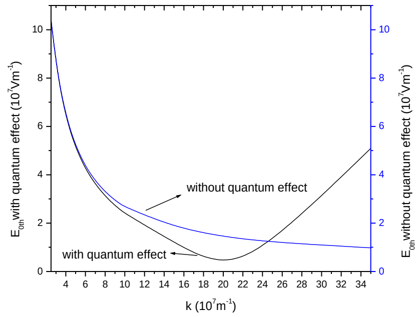
Figure 1 :



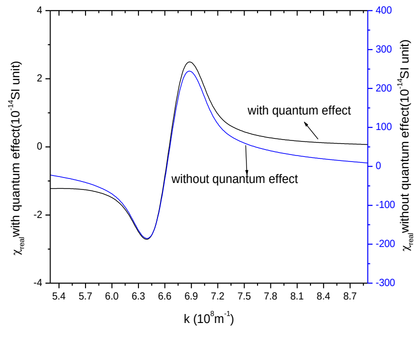
Variation of threshold electric field (with and without quantum effect) E_{0th} with wave vector k when $n_0 = 10^{24} m^{-3}$.

2. Dispersion characteristics

In this section the numerical analysis dealing with the external parameters influencing the parametric dispersion arising due to the real part of the third order susceptibility, viz., $[\chi^{(3)}_{real}]$ for the onset of modulational amplification process are plotted in fig. (2) and (3). From the figures (2) and (3) it is clear that the variation of $[\chi^{(3)}_{real}]$ with k and n_0 are identical in both the cases (with and without quantum effect). The only difference lies in the corresponding magnitudes. The susceptibility profile is similar to the dispersion characteristics of III-V semiconductors.

It can be observed that $[\chi^{(3)}_{real}]$ exhibits the usual dispersive characteristics of a medium with complex refractive index. Figure (2) shows the behavior of $[\chi^{(3)}_{real}]$, obtained from the equation (15a) with respect to k. Initially the curve shows that when $kV_a << \omega_a$, both the real part of susceptibilities (with and without quantum effect) are negative quantity and remains constant with k. On further increase in k the susceptibility $[\chi^{(3)}_{real}]$ abruptly decreases and attains its minimum value $[\chi^{(3)}_{real}] = -3.28 \times 10^{-14} m^2 V^{-2}$ (with quantum effect) and $[\chi^{(3)}_{real}] = -290 \times 10^{-14} m^{-2} V^{-2}$ (without quantum effect) at $k = 6.5 \times 10^8 m^{-1}$. A slight increase in k beyond this point cause a sharp rise in $[\chi^{(3)}_{real}]$, making it vanish at resonance peak when $kV_a \approx \omega_a$. After this resonance condition, $[\chi^{(3)}_{real}]$ increases sharply and then again decreases rapidly and becomes constant at larger values of wave vector.

Figure 2 :



Variation of real part of the susceptibility $[\chi^{(3)}_{real}]$ with wave number k with and without quantum effect.

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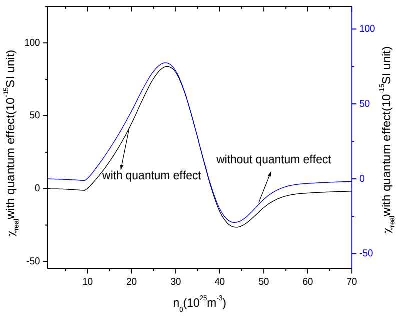
Real part susceptibility $[\chi^{(3)}_{real}]$ has been analyzed in figure 3 for the cases with and without quantum effect as a function of n_0 at a particular value of the pump electric field E_0 in the vicinity of E_{oth}. It may be infer from figure that the susceptibility for both the cases can be negative and positive sign. For $\omega_p < \omega_1$, susceptibility increases with n_0 then when $n_0 = 4\times10^{26}m^{-3}$ susceptibility changes the sign attributing negative dispersion (absorption) characteristics at resonance condition $(\omega_p \approx \omega_1)$. After this resonance condition as increase in carrier concentration the susceptibility acquires negative values and saturates at larger values of n_0. effectively reduce the electron bunching and consequently gain will be reduced.

Figure 3 :



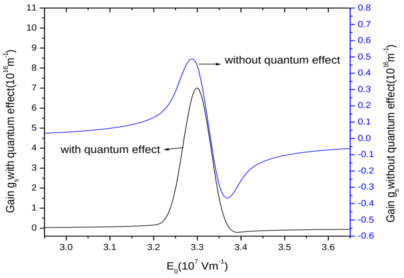
Variation of the real part of the susceptibility $[\chi^{(3)}_{real}]$ with carrier concentration n_0 at $E_0 = 1.6\times10^7 Vm^{-1}$ and $k = 2.3\times10^7 m^{-1}$.

It may be inferred from figures 2 and 3 that a proper selection of wavelength regime and doping concentration we can achieve either positive or negative significantly enhanced parametric dispersion.

3. Amplification Characteristics

Figure 4 shows the dependence of gain coefficient associated with the modulation process on the pump electric field E_0 at $k = 3.2\times10^7 m^{-1}$.We have drawn two curves in presence and absence of quantum correction. It is found that initially gain is nearly independent of E_0 up to $E_0 \approx 3.2\times10^7 Vm^{-1}$. In this regime, natures of variation of gain for both the cases (with and without quantum effect) are identical and gain is modified due to presence of quantum effect. This figure depicts that the gain increases rapidly with increase in E_0 and attains its maximum $(g_s \approx 10.52\times10^{16} m^{-1})$ $E_0 = 3.301\times10^7 Vm^{-1}$ (with quantum effect) and $(g_s = 0.753\times10^{16} m^{-1})$ $E_0 = 3.285\times10^7 Vm^{-1}$ (without quantum effect). A slight increase in the value of E_0 beyond this point yields a sudden fall in the value of gain in both cases up to $E_0 = 3.35\times10^7 Vm^{-1}$ and again becomes independent of E_0 with a negligible negative value. In this regime also, quantum correction is found responsible for increment in gain. It is observed that in presence of quantum term the gain attains its maximum and minimum value at higher pump amplitude. Hence, one may infer from this figure that to achieve a high gain coefficient, the input pump amplitude should lie between $E_0 = 3.2\times10^7 Vm^{-1}$ and $E_0 = 3.35\times10^7 Vm^{-1}$ for the parameter range under study.

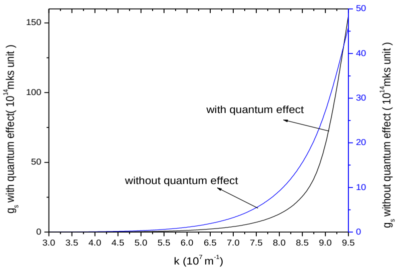
Figure 4 :



Variation of gain g_s with pump field amplitude E_0 when $n_0 = 6\times10^{24} m^{-3}$ and $k = 3.2\times10^7 m^{-1}$.

The numerical estimations {using Eq.(17)} dealing with the wave number k influencing the growth rate g_s are plotted in figure 5 at $E_0 = 10^7 Vm^{-1}$ and $n_0 = 4\times10^{24} m^{-3}$ in presence and absence of quantum term. One may infer from the graph that g_s increases sharply with k when $\omega_a >> k_a V_a$. The similar effect of wave number k on modulated growth rate in electrostrictive semiconductor plasma was reported by Ghosh and Yadav 2007 [24] but in present study author gets the high growth rate with materials of high dielectric constant in presence of quantum term through Δ in equation (17) as compared to them. Hence quantum effect is found to be responsible for increasing the growth rate.

Figure 5 :



Variation of gain g_s with wave number k with and without quantum effect.

IV. CONCLUSION

Our analytical and numerical study on MI process in semiconducting quantum plasma with SDDC shows that the frequency modulation of plasma waves is affected significantly by the quantum effect. Based on the above results we present the following conclusions-

1. The method is use in this study have many advantages for applications in fabrication of any nonlinear device which also demanded an extensive theoretical as well as experimental study.
2. In presence of quantum term threshold pump amplitude required for the incite MI process reduces by adjusting the wave number range which is of chief importance in designing the semiconducting devices.
3. With quantum effect we get higher gain coefficients at high wave length regime.

It is hoped that the diffusion-induced third-order nonlinearity in strain dependent dielectric materials may play a key role in the development of ultrafast modulator, micro-structured optical fibers etc.
his fragment should obviously state the foremost conclusions of the exploration and give a coherent explanation of their significance and consequence.

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