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Raman Instability of An Intense Helicon Wave in Longitudinally Magnetized Ferroelectric Semiconducting Plasma

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ABSTRACT

The comprehensive study of Raman instability of the scattering helicon waves in longitudinally magnetized. The general disperson relatinon is obtained by using hydrodynamic model and coupled mode theory to considered that due to the scattering of bothe molecular vibrational procedure and pump wave for tranverse optical phonon and electron plasma wave at same frequency. The dispersion relation is solved for both the cases of scattered helicon waves. The threshold value of the pump amplitude necessary for the onset of instability and the growth rate well above the threshold are obtained analytically for both the modes. The analysis is applied to a specific semiconductor, BaTiO3 at 77K duly irradiated by a high power helicon wave for numerical estimations. The laser wave intensities used are in the range of 10^{12} to 10^{13} Wm-1 which is assumed to be less than the damage threshold of the semiconducting crystal. The order of wave amplitude is feasible presently.

KEYWORDS Raman Instability, Hydrodynamic Model, Strain Dependent Dielectric Constant (SDDC), High Dielectric Constant (HDC).

Introduction:

The Stimulated Raman Scattering process was discovered by Eckhardt et al. (1962) [1], He found when a ruby laser beam of sufficient intensity was incident on a cell containing intro-benzene. Then stimulated Raman beam was emitted, which was placed within the resonator. Raman spectroscopy is used as a tool for studying the vibrational energy levels of molecules and lattice vibrations of the optical branch in crystals[2]. Recently Apte et. al. [3] and Ghosh et. al. [4] have given a simplified analytical treatment of SRS phenomenon of a large amplitude, linearly polarized, electromagnetic pump wave and the molecular vibrations produced at a frequency equal to that of transverse optical phonons. They studied the Raman instability and consequent amplification of linearly polarized electromagnetic wave [3] and helicon wave [4], respectively, in an magneto active n-type piezoelectric semiconductor.

Manvir S. Kushwaha et. al. discussed that the plasmon excitations in synthetic semiconductor heterostructures. The plasmons are now often used as a diagnostic tool to characterize the electronic structure of new materials. The surface plasmon becoming known as plasmon polariton is simply an Electro-Magnetic wave that propagates along the interface separating the two media. However the development of the principles, tools, and the applications of the model theories were applied to diverse geometries of heterostructures. They focussed their attention is largely given to the non-radiative modes, scrutinizing the effects of an applied magnetic field, carrier collisions, retardation, interaction with optical phonons and to the intrasubband modes, which could be investigated through the use of classical as well as quantal approaches. The numerous theoretical results on plasmons and magnetoplasmons in several geometries of practical interest have been gathered and reviewed. This survey is preceded by the basics of several methodologies (both classical and quantal) which were relevant to a wide variety of systems of changeable interest. The report concludes addressing briefly the anticipated implications of plasmon observation in the respective composite systems under a variety of circumstances [5].

The comprehensive study of Raman instability and scattering of laser beam for ferroelectric semiconducting plasma. In this paper an important phenomenon of stimulated stokes Raman scattering

in a narrow-gap in ferroelectric semiconducting crystal duly irradiate by an intense helicon pump wave was discribed. We used the particular geometry where the incident high power helicon laser laser radiation also known as pump wave, $\mathbf{E}_0\exp[i(\Omega t-k_0 z)]$ is applied along the directions of the externally applied static magnetic field $\mathbf{B_0}\|\mathbf{k_0}\|\hat{\mathbf{Z}}$. The propagation vectors $\mathbf{k}$ and $\mathbf{k_1}$ of generated density perturbation $(\boldsymbol{\Omega}, \mathbf{k})$ and the helicon wave $(\boldsymbol{\Omega_1}, \mathbf{k_1})$ are also along the z-direction. The physical origin of the phenomenon lies in the non vanishing , nonlinear, polarization due to the coupling of the molecular vibrations having a frequency equal to the transverse optical phonon frequency Ω_T with the pump at frequency $\boldsymbol{\Omega_0}$, as well as the electron plasma wave at frequency Ω_p in the presence of a magneto static field such that $\boldsymbol{\Omega_T < \Omega_p < \Omega_0}$, and the electron cyclotron frequency $\Omega_c(<\Omega_0) \gg \Omega_T[=\frac{1}{2}(\Omega_T^2+\Omega_p^2)^{\frac{1}{2}}]$. We have investigated analytically the threshold condition for the onset of instability, as well as the growth rate of the unstable. Raman mode well above the threshold value of the pump electric field. The analysis is based on the coupled mode theory [6,7] which was employed earlier by Ghosh et. al. [3, 4] for a simplified treatment of the Raman instability. The SRS is discussed using the hydrodynamic model of the one-component (electrons) semiconducting plasma where kl<<1, where k and l are the wave number of the density fluctuation produced and the electron mean free path, respectively. As the authors are interested in the instability of the stokes component of the raman instability oa intense helicon n wave, the selection rules satisfied are as follows:

$$\Omega_0 = \Omega_1+\Omega, \qquad k_0=k_1+k.$$

In this paper, investigation has been made under the following assumptions:

(i) the electric field amplitude of the pump employed in the present investigation has been taken to be less than the damage threshold of the crystal considered; (ii) we have neglected the effect of nonlinear material parameters by restriction our analysis to the moderately piezoelectric semiconductors [8], viz. III-V binary compounds;

(iii) The semiconductors have an isotropic and nondegenerate band;

(iv) the band nonparabolicity which contribute above 3% over the parabolic band structure has been neglected;

(v) the employed electric field amplitude of the pump has been taken to be less than the low frequency threshold for impact ionization for magneto active III-V binary semiconductors;

(vi) we have neglected the thermal effect, because for highly doped semiconductors one can have $\Omega_p^2 >> k^2 v_{th}^2$ (Ω_p and v_{th} being the electron plasma frequency and electron thermal velocity, respectively).

The nonlinearities which have been taken into account are the nonlinear current and the polarization, which is the cause of nonlinear coupling between the density fluctuations at frequency Ω and the helicon pump wave at frequency Ω_0.

We have made through numerically assessment of the entities like the conditions for the on set of instability and growth rate of the unstable helicon modes at fields well above the threshold pump amplitude necessary to incite the instability in semiconducting crystal.

Theoretical Formulation:

We considered the hydrodynamic model of a homogeneous one-component semiconductor plasma having an isotropic and nondegenerate conduction band under the geometrical configuration In a Raman-active medium the scattering of a large-amplitude helicon pump wave is enhanced due to the excitation of a molecular vibrational mode. The analysis the Raman medium is taken as consisting of N harmonic oscillators per unit volume: each oscillator is characterized by its position z and normal vibrational coordinate u(z,t). The equation of motion for a single oscillator is

$$\frac{\partial^2 u(z,t)}{\partial t^2} + \Gamma \frac{\partial u(z,t)}{\partial t} + \Omega_T^2 u(z,t) = \frac{F(z,t)}{M} \qquad (1)$$

where Γ is the damping constant equal to the phenomenological phonon collision frequency ($\approx 10^{-2}\Omega_T$) [9,3, 6], Ω_T being the undamped molecular vibrational frequency, and is taken to be unit volume, which can be obtained by considering the electromagnetic energy in the presence of the molecules, and in polarizable material F(z,t) is given by

$$F(z,t) = \frac{1}{2}\varepsilon_0 \varepsilon_\infty \left(\frac{\partial \alpha}{\partial u}\right)_0 \bar{E}^2(z,t), \qquad (2)$$

Where ε_0 and ε_∞ are the absolute permittivity and the high-frequency permittivity correspondingly; $\left(\frac{\partial \alpha}{\partial u}\right)_0$ is the discrepancy polarizability and the bar over E indicates the averaging over a few optical periods, as the molecules cannot respond to optical frequencies. This shows that because of the non-vanishing polarizability $\left(\frac{\partial \alpha}{\partial u}\right)_0$ the molecular vibration can be driven by the electric field. The other basic equations involved in the analysis are:

$$\frac{\partial v_0}{\partial t} + (v_0.\nabla)v_0 + \nu v_0 = -\frac{e}{m}(E_0 + v_0 \times B_s + v_0 \times B_0), \qquad (3)$$

$$\frac{\partial v}{\partial t} + (v_0.\nabla)v + \nu v = -\frac{e}{m}(E + v_0 \times B + v \times B_s), \quad (4)$$

$$\frac{\partial n}{\partial t} + (v_0.\nabla)n + n_0(\nabla.v) = 0, \quad (5)$$

$$\frac{\partial E}{\partial x} = \frac{en}{\varepsilon} - \frac{\varepsilon_0 g E_0}{\varepsilon}\frac{\partial^2 u}{\partial x^2}, \quad (6)$$

$$\nabla \times E = -\frac{\partial B}{\partial t}, \quad (3)$$

$$\nabla \times H = J + \frac{\partial D}{\partial t}, \quad (4)$$

$$D = \varepsilon E + \varepsilon_0 g E_0 \frac{\partial u}{\partial z}. \quad (9)$$

$$P = \varepsilon N \left(\frac{\partial \propto}{\partial u}\right)_0 u. \quad (10)$$

Equation (3) is the zeroth-order equation of motion of electrons and shows that electrons will oscillate under the influence of the applied time-varying electric field. The space-charge field *E* is determined by the passion equation (6) in which the second term on the right-hand side gives the ferroelectric contribution to polarization, n is the electron density perturbation, and ε the dielectric constant of the semiconductor. Equation (4) and (5) are the momentum and continuity equations for electrons. These equations are appropriate for nondegenerate semiconductors. In (3), (4) and (5) we have assumed a scalar effective mass for the electrons. Equation (10) represents the nonlinear polarization, N being number of molecules per unit volume. The molecular vibration at frequency Ω cause a modulation of the dielectric constant and leads to energy exchange between the electromagnetic fields separated in frequency by multifles of Ω [i.e., $(\Omega_0 \pm p\Omega)$, where p = 1,2,3…..]. The modes at frequencies $\Omega_0 + p\Omega$ are known as anti-stokes, while those at $\Omega_0 - p\Omega$ are stokes modes.

In this paper, the authors consider the exchange only between the laser field at frequency Ω_0 and the stokes field at frequency $\Omega_0 - \Omega(= \Omega_1)$. Using (1) and (2), the complex amplitude of the molecular vibration driven at a frequency $\Omega(= \Omega_0 - \Omega)$ is obtained as

$$u = \frac{\varepsilon\left(\frac{\partial x}{\partial u}\right)_0 E_0 E_1^*}{2M\{\Omega_T^2 + i\Gamma\Omega\}}, \quad (11)$$

where E_1^* represents the complex conjugate of the scattered circularly polarized electromagnetic wave amplitude. The use of (6) and (11) yields the perturbed electron density (n_T) due to molecular vibrations as

$$n_T = \frac{i\varepsilon k}{e}\left[\frac{\Omega_T^2-\Omega^2+i\Omega\Gamma-\frac{ik\varepsilon_0 gE_0}{2M}\left(\frac{\partial x}{\partial u}\right)_0 E_0}{\frac{\varepsilon}{2M}\left(\frac{\partial x}{\partial u}\right)_0 E_0}\right]u. \qquad (12)$$

The density perturbation associated with the molecular vibrations at frequency Ω beats with the pump frequency Ω_0 and produces fast components of the density perturbation at frequencies $(\Omega_0 \pm p\Omega)$. We consider only the fast component which is associated with the stokes mode and has a frequency $\Omega_0 - \Omega$ (viz., n_s). Using (3) to (6) and the following Ghosh et al., [27] one gets n_s as

$$n_s = \frac{i(k+k_0)E_0 n_T}{\Omega_1^2+\Omega_R^2-i\Omega_1(\nu - ikv_{0z})} \qquad (13)$$

where suffixes T and S denote the components of the perturbed carrier concentration associated with the molecular vibrations and the stokes mode, respectively. In (13)

$$\Omega_R^2 = k^2v_{th}^2 + \frac{\Omega_P^2\Omega_L^2}{\Omega_T^2}\frac{\bar{\Omega}}{\Omega}, \quad \left(\frac{\Omega_L}{\Omega_T}\right)^2 = \frac{\varepsilon_L}{\varepsilon_\infty}, \quad \Omega_P^2 = \frac{n_0e^2}{m\varepsilon_0\varepsilon_L}, \; v_{th} = \left(\frac{k_BT}{m}\right)^{1/2},$$

$$\bar{E}_0 = \frac{e}{m}\frac{\bar{\Omega}_0}{\Omega_0}E_{0\pm} \mp i\Omega_0 v_{0\pm}.$$

Ω_L is the longitudinal optical phonon frequency and is given by $\Omega_L = \frac{k_B\theta_D}{\hbar}$, where θ_D is the Debye temperature of the lattice. ε_L is the permittivity of the crystal and v_{th} the thermal velocity of the electrons. The oscillatory electron fluid velocity v_0 is obtained from (3), assuming the proportionality of the pump to $\exp(i\Omega_0 t)$, as

$$v_{0\pm} = \frac{ie}{m}\left[\frac{\bar{\Omega}_0/\Omega_0}{(\bar{\Omega}_0 - iv\mp\Omega_c)}\right], \qquad (14)$$

which is only in the z- direction and independent of the magnetic field B_s applied along the same direction as the pump.

we assume that perturbations are proportional to the factor $exp[i(\Omega_T - kz)]$. using (4) and (6) to (8), the components of the perturbed velocity v are obtained as

$$v_{\pm} = \frac{ie}{m}\left[\frac{\bar{\Omega}_0/\Omega_0}{(\bar{\Omega}_0 - iv \mp \Omega_c)} E_{\pm}\right], \tag{15}$$

where $\bar{\Omega} = \Omega - k.v_0$). In obtained (15), we have taken $v_{\pm} = v_x \pm i\, v_y$, $B_{\pm} = B_x \pm i\, B_y$, and $E_{\pm} = E_x \pm i\, E_y$, where the minus and plus signs correspond to the right- hand and left-hand circular polarizations, respectively. Using (7) to (10), we obtain the general wave equation, as

$$\nabla \times \nabla \times E = -\mu_0 \frac{\partial J}{\partial t} - \mu_0 \varepsilon \frac{\partial^2 E}{\partial t^2} - \mu_0 \varepsilon N \left(\frac{\partial x}{\partial u}\right)_0 \frac{\partial^2}{\partial t^2}(u^* E) \tag{16}$$

in which J is the perturbed current density and is given by

$$J = n_0 ev + nev_0 \tag{17}$$

the component of which are obtained by using (12) to (15) in (17), as

$$J_{\pm} = \frac{-i\varepsilon}{\Omega_1(1-Q)}\left[\frac{\Omega_P^2 \Omega_L^2}{\Omega_T^2(\bar{\Omega} - iv \mp \Omega_c)} + Q\left(k^2 C_L^2 - \Omega_1^2\right)\right] E_{\pm}, \tag{18}$$

where

$$Q = \frac{i\varepsilon v_{0\pm}}{\Omega \varepsilon_0 g E_0}\left[1 + \frac{i(k+k_0)\bar{E}_0}{(\Omega_1^2 + \Omega_R^2 - i\Omega_1(v - ikv_{0z})} \times \frac{\Omega_T^2 - \Omega^2 + i\Omega\Gamma - \left(\frac{ik\varepsilon_0 g E_0}{2M}\right)\left(\frac{\partial x}{\partial u}\right)_0 E_{\pm}}{\left(\frac{\varepsilon}{2M}\right)\left(\frac{\partial x}{\partial u}\right)_0 E_{0\pm}}\right] \tag{19}$$

In deriving (18), we have expressed $u_{\pm}$ in terms of $E_{\pm}$ employing (8) as

$$u_{\pm} = -\frac{J_{\pm}}{k\Omega\varepsilon_0 g E_0} + \frac{i\varepsilon}{k\Omega\varepsilon_0 g E_0}\left(k^2 C_L^2 - \Omega^2\right) E_{\pm}, \tag{19}$$

where $C_L^2 (= \frac{1}{(\mu_0 \varepsilon_0 \varepsilon_L)}$ is the velocity of light in the crystal.

The general wave equation (16) is now considered which represents the scattered helicon wave with frequency $\Omega_1$and number $k_1 (\approx k\ as\ k_0 = 0)$, and varying as $exp[i(\Omega_1 t - k_1 z)]$. Under the chosen configuration, (16) reduces to

$$-k^2 E_{\pm} + i\Omega_1 \mu_0 J_{\pm} - \frac{\Omega_1^2}{C_L^2} E_{\pm} = \mu_0 \varepsilon N \left(\frac{\partial x}{\partial u}\right)_0 \frac{\partial^2}{\partial t^2}\left(u_{\pm}^* E_{\pm}\right). \tag{20}$$

the use of (11) and (17) to (19) in (20) for the scattered helicon wave Ω_1, k_1 yields the general dispersion relation for the phenomenon of SRS,

$$\left[\left(k^2C_L^2+\Omega_1^2\right)-\frac{\Omega_1\Omega_P^2\Omega_L^2\left(\frac{\bar{\Omega}}{\Omega}\right)}{\Omega_T^2(1-Q)(\bar{\Omega}-iv_{\mp}\Omega_c)}-\frac{Q}{(1-Q)}\left\{k^2C_L^2-\Omega_1^2\right\}+\frac{\Omega_1^2\left(\frac{\varepsilon N}{2M}\right)\left(\frac{\partial x}{\partial u}\right)_0^2E_{0\pm}^2}{\left(\Omega_T^2-\Omega^2+i\Omega\Gamma\right)}\right]E_{\pm}=0. \quad (21)$$

1,3 Instability of Raman Mode

Equation (21) may be rewritten in a simple form as

$$(\Omega_T^2-\Omega^2+i\Omega\Gamma))[k^2C_L^2(1-Q)(\mp Q_c)-\bar{\Omega}_1\Omega_R^2)]=-\Omega_1^2D(1-Q)(\mp\Omega_c) \quad (22)$$

In which

$$D=\frac{\varepsilon N}{2M}\left(\frac{\partial x}{\partial u}\right)_0^2E_{0\pm}^2 .$$

In obtaining (22) from (21), we have assumed

$k^2C_L^2 \gg \Omega_1^2$ (quasistatic limit), $\Omega_c\left(\approx\Omega_p\right)\gg v\gg\Omega_1,\bar{\Omega}_1$, $\frac{\Omega_L^2\Omega_p^2\bar{\Omega}_1}{\Omega_1\Omega_T^2(\bar{\Omega}_1-iv\mp\Omega_c)} >> \frac{Q}{\Omega_1}(k^2C_L^2-\Omega_1^2)$,

$k^2v_{th}^2\frac{\Omega_L^2\Omega_p^2}{\Omega_T^2}$ so that $\Omega_R^2\approx\frac{\Omega_L^2\Omega_p^2}{\Omega_T^2}$.

In order to explore the possibility of SRS and the Raman instability in an n- type electric semiconductor crystal, we solve the above equation with complex Ω ($=\Omega_r+i\Omega_i$) and real positive value of k. To make the analysis simplified, we assume $\Omega_T\approx\Omega_r<\Omega_p$, $\Omega_r > kv_{0z}$, v and $\Omega_i < v<\Omega_r$. It is also well known that mode will be unstable only when $\Omega_i<0$, and the threshold value of the pump amplitude E_{0th} is obtained at $\Omega_i=0$. Thus, separating real and imaginary parts of (22), one gets

$$\Omega_i=\ \mp\frac{\Omega_1^2D\bar{Q}\Omega_c}{2\Omega_r[\Omega_1\Omega_R^2\pm k^2C_L^2\Omega_c]}+\frac{\Gamma}{2}, \quad (23)$$

$$Q=\mp\frac{2e\Gamma M}{m\varepsilon_0gE_0\Omega_c\left(\frac{\partial x}{\partial u}\right)_0}$$

obtaining the above expression for Q, it has been assume that

$$\frac{i(k+k_0)\bar{E}}{\Omega_1^2-\Omega_R^2-i\Omega_1(v-ikv_{0z})}\ll 1, \quad \Omega_r^2\approx\Omega_T^2, \text{ and } i\Omega\Gamma>\frac{ik\varepsilon_0gE_0\left(\frac{\partial x}{\partial u}\right)_0E_0}{2M}.$$

in (8). In (23) the upper and lower signs correspond to right and left hand circularly polarized modes, respectively.

3.1 case 1: right hand circularly polarized mode

For right hand circularly (R) polarized mode (23) may be rewritten as

$$(\Omega_i)_R = \frac{-\Omega_1^2 D\overline{Q}\Omega_c}{2\Omega_r[\overline{\Omega}_1\Omega_R^2 \pm k^2 C_L^2\Omega_c]} + \frac{\Gamma}{2} \qquad (24)$$

The scattered R polarized Raman mode can become unstable only when $Q_i < 0$; thus the condition for the Raman instability becomes

$$\left|\frac{\Omega_1^2 D\overline{Q}\Omega_c}{2\Omega_r[\overline{\Omega}_1\Omega_R^2 \pm k^2 C_L^2\Omega_c]}\right| > \left|\frac{\Gamma}{2}\right|. \qquad (25)$$

This condition can be achieved by adjusting the electron concentration and the magnitude of the applied magnetostatic field. In the absence of $E_0(D = 0)$, the growth rate disappears and the wave attenuates with an attenuation factor $\frac{\Gamma}{2}$. Thus, one infers from (24) that E_0 must be finite and should have a threshold value for the onset of Raman instability. The threshold value is obtained by equating Ω_i to zero in (24)which yields

$$(E_{0th})_R = \left[\frac{\varepsilon_0 g E_0 \Omega_r\left(m\overline{\Omega}_i\Omega_R^2 + k^2 C_L^2\Omega_c\right)}{\Omega_1^2 e\varepsilon N\left(\frac{\partial x}{\partial u}\right)_0}\right]^{1/2}, \qquad (26)$$

The growth at an electric field larger than the threshold electric field is obtained by using condition (25) in (24) as

$$|\Omega_i|_R = \frac{\Omega_1^2 e\Gamma\varepsilon N\left(\frac{\partial x}{\partial u}\right)_0 E_0^2}{2\Omega_r m\varepsilon_0 g E_0[\Omega_1\Omega_R^2 + k^2 C_L^2\Omega_c]}. \qquad (27)$$

One can note from (27) that the growth rate of the unstable R polarized Raman mode well above the threshold varies as the square of the pump amplitude. the threshold pump amplitude can be increased by increasing the carrier concentrations as is evident from the term $[k^2 C_L^2\Omega_c + \overline{\Omega}_1\Omega_R^2]$ in (26). From (26) and (27) it may be noted that the threshold pump amplitude and the growth rate well above the threshold of the unstable R polarized Raman mode are dependent on the piezoelectric nature of the semiconductor for the configuration.

3.2 Case2: Left- hand circularly polarized mode

For left-hand circularly (L) polarized mode, may be written as

$$(\Omega_i)_R = \frac{\Omega_1^2 D\overline{Q}\Omega_c}{2\Omega_r[\overline{\Omega}_1\Omega_R^2 - k^2C_L^2\Omega_c]} + \frac{\Gamma}{2}. \quad (28)$$

The scattered L polarized Raman Mode can become unstable only if $\Omega_1 < 0$

(i) $\left|\frac{\Omega_1^2 D\overline{Q}\Omega_c}{2\Omega_r[\overline{\Omega}_1\Omega_R^2 \pm k^2C_L^2\Omega_c]}\right| > \left|\frac{\Gamma}{2}\right|,$ (29a)

(ii) $\overline{\Omega}_1\Omega_R^2 > k^2C_L^2\Omega_c.$ (29b)

These conditions are the same as the obtained for the excitation of R polarized Raman mode (25). The only marked difference between both modes are that the L polarized mode is unstable only when $\overline{\Omega}_1\Omega_R^2 > k^2C_L^2\Omega_c$ whereas the R polarized mode can be unstable even under opposite condition.

In the absence of $E_0(D = 0)$, the growth rate of L polarized mode disappears and it attenuates with an attenuation constant $\frac{\Gamma}{2}$. Thus one can infer from (28) that E_0 must be finite and should have a threshold value for the onset of a Raman instability. The threshold value is obtained by equating Ω_i to zero in (28), which yields,

$$(E_{0th})_L = \left[\frac{\Omega_r m\varepsilon_0 g E_0(\overline{\Omega}_i\Omega_R^2 - k^2C_L^2\Omega_c)}{\Omega_1^2 e\varepsilon N\left(\frac{\partial x}{\partial u}\right)_0}\right]^{1/2}, \quad (30)$$

The growth rate at an electric field well above the threshold electric field is obtained by using condition (29) in (28) as

$$|\Omega_i|_L = \frac{\Omega_1^2 e\Gamma\varepsilon N\left(\frac{\partial x}{\partial u}\right)_0 E_{0-}^2}{2\Omega_r m\varepsilon_0 g E_0[\Omega_1\Omega_R^2 - k^2C_L^2\Omega_c]}. \quad (31)$$

The growth rate of the unstable L polarized Raman mode well above the threshold varies as the square of the pump amplitude. The threshold pump amplitude increases with increases with increase in carrier concentration, whereas the growth rate decreases with increase in carrier

concentration. The growth rate as well as threshold pump amplitude depend upon the piezoelectric nature of the material for the chosen configuration.

Results and discussion:

The analytical investigation of stimulated Raman scattering of high-power helicon pump wave and resulted instability have been dealt with in the present paper. The analytical results obtained are applied to a semiconductor like $BaTiO_3$ at 77K. The analytical constants taken are $m = 0.014m_0$, $\varepsilon_0 g E_0 = 0.054$, $\varrho = 5.8 \times 10^{15} kgm^{-3}$, $\varepsilon_L = 17.8$, $\nu = 3.5 \times 10^{12} s^{-1}$ $\varepsilon_\infty = 15.68$, $C_s = 4 \times 10^3 ms^{-1}$, and the carrier concentration $n_0 = 10^{23} m^{-1}$. The other constant are $N = 1.48 \times 10^{28} m^{-1}$, $\Omega_T = 3.7 \times 10^{15} s^{-1}$, and the polarizability $\left(\frac{\partial x}{\partial u}\right)_0$ from Debye temperature of $BaTiO_3$ semiconducting crystal (278K), molecular weight of $BaTiO_3$ (233.192 g/mol), and that the crystal is irradiated with an intense helicon laser beam. The results are plotted in Fig. 1 to 3. Fig. 1 show the variation of threshold electric field amplitudes $(E_{0th})_R$ and $(E_{0th})_L$ with magnetostatic field (in terms of Ω_c) at $k = 2 \times 10^7 m^{-1}$ from which one can infer that $(E_{0th})_R$ increases rapidly (curve 1) whereas $(E_{0th})_L$ decreases (curve 2) with increasing Ω_c. The variations of growth rates $|\Omega_i|$ with Ω_c at $k = 2 \times 10^7 m^{-1}$ and $E_0 = 1 \times 10^7 V m^{-1}$ have been shown in Fig.2. (curve 1) shows that $|\Omega_i|_L$ increaes with Ω_c but the reverse is the case with $|\Omega_i|_R$ as may be seen from curve 2. Fig. 3 represents the dependences of growth rates $|\Omega_i|$ on threshold electric field amplitude E_0 where $E_0 > E_{0th}$, $\Omega_c = 1.5 \times 10^{15} s^{-1}$ and $k = 2 \times 10^7 m^{-1}$. One can infer from curve 1 and 2 that as E_0 is increased the growth rates $|\Omega_i|_R$ and $|\Omega_i|_L$ increased very sharply. But one always gets higher values of $|\Omega_i|_L$ and $|\Omega_i|_R$, as is evident from curve 1 ($|\Omega_i|_L$) and curve 2 ($|\Omega_i|_R$).

The electric field amplitude considered in the present investigation can be expressed in terms of pump intensity I_0 by using the relation $I_0 = c_0 \varepsilon_0 \varepsilon_\infty |E_0|^2 / 2\eta$. η being the refractive index of the crystal (4.9 for $BaTiO_3$) and c_0 is the velocity of light in vacuum. The result reported in this are made for E_0 in the range of 10^7 to 6×10^8 Vm^{-1}, the corresponding range of I_0 using the above relation becomes 6.66×10^{10} to 2.18×10^{15} Wm^{-3}. Such values of electric field can be obtained by using a high power helicon which is experimentally feasible[28].

Graphs-

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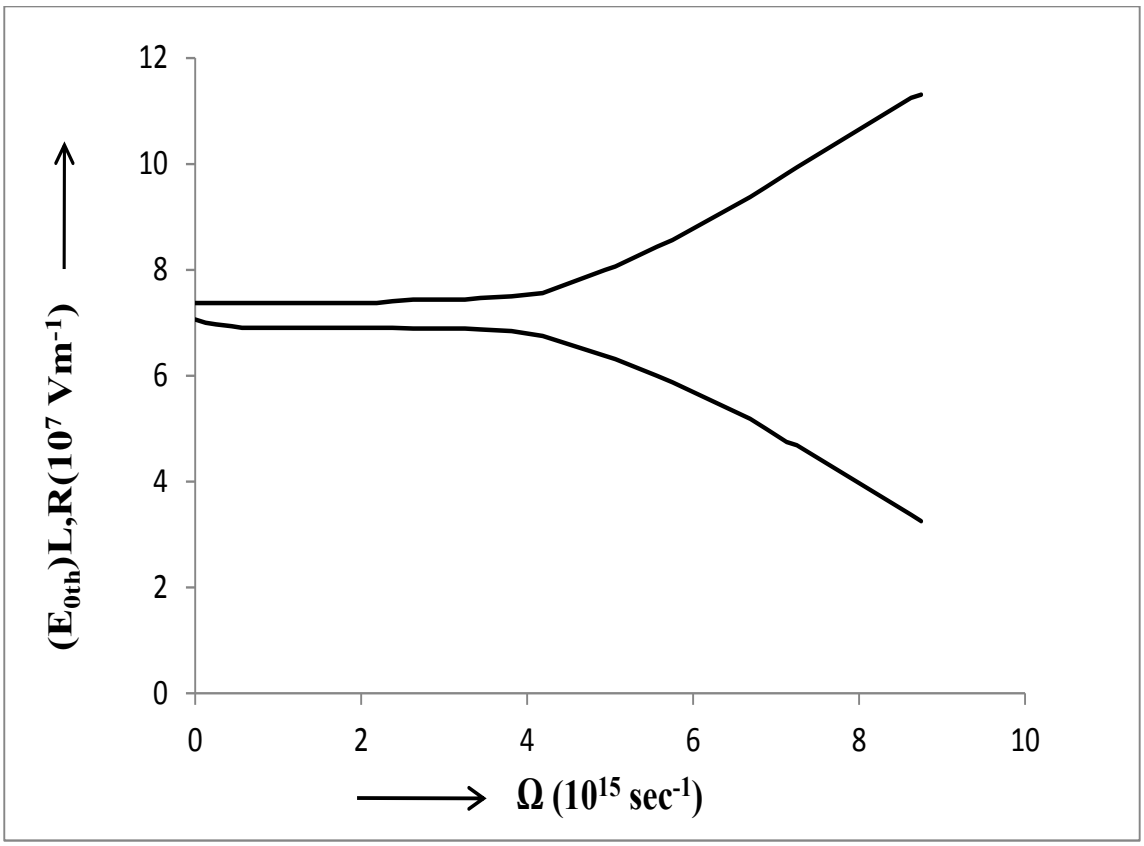

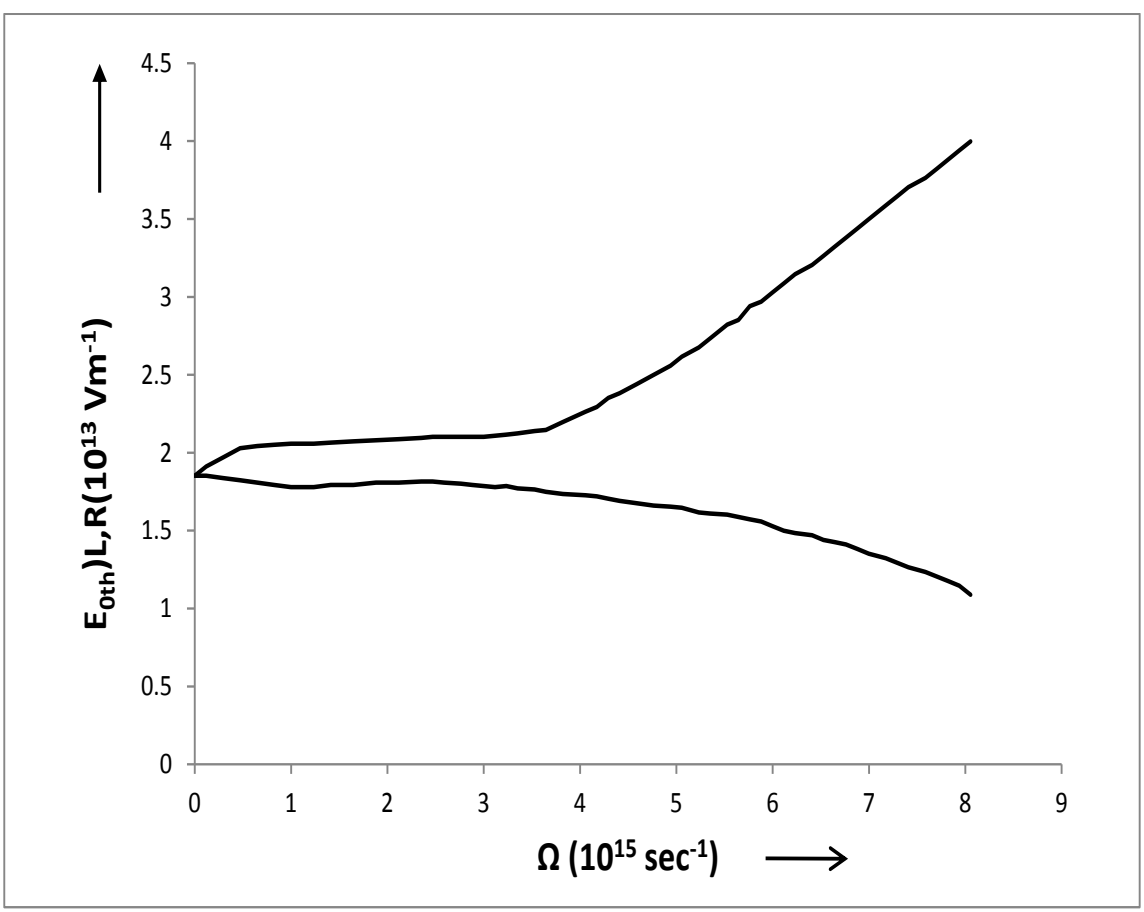

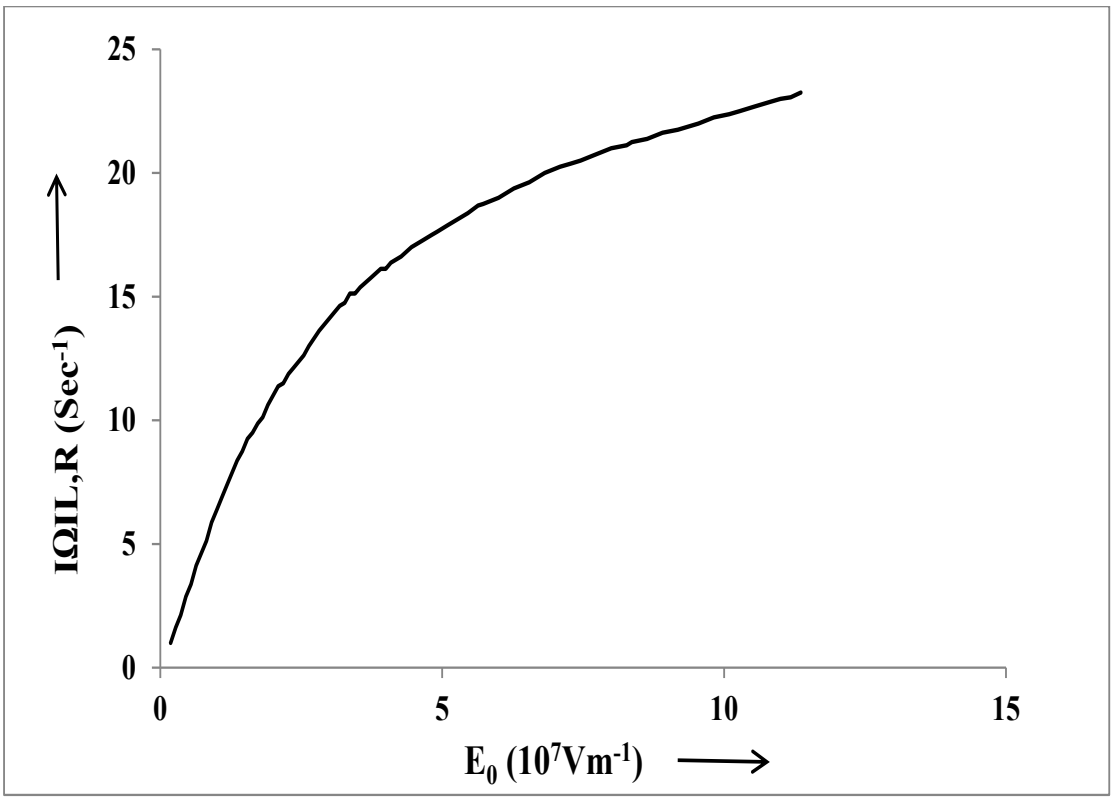

Fig. 1. Variation of threshold electric field amplitudes $(E_{0th})_R$ (curve 1) and $(E_{0th})_L$ (curve 2) with magnetostatic field (in terms of Ω_c) at $k = 2 \times 10^6\ m^{-1}$.

Fig. 2 Variation of growth rate $|\Omega i|_L$ (curve 1) and $|\Omega i|_R$ (curve 2) with Ω_c at $k = 2\times 10^6\ m^{-1}$ and $E_0 = 1 \times 10^6\ Vm^{-1}$

Fig. 3. Variation of growth rate $|\Omega i|_L$ (curve 1) and $|\Omega i|_R$ (curve 2) with threshold electric field amplitude E_0 where $E_0 > E_{0th}$ at $\Omega_c = 1.5\times 10^{14}\ s^{-1}$ and $k = 2\times 10^6\ m^{-1}$.

Thus result of this paper suggest that in a longitudinally magnetized semiconductor plasma one can obtain considerable growth rates of unstable Raman modes (scattered helicon mode) when the crystals is irradiated by an intense helicon laser beam.

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