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Stimulated Brillouin scattering of laser radiation in a piezoelectric semiconductor: Quantum effect

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Using quantum-hydrodynamic model, the phenomenon of the stimulated Brillouin scattering of a laser radiation in an unmagnetized piezoelectric semiconductor has been examined in detail. It is noticed that the Bohm potential in the electron dynamics of the semiconductor plasma enhances drastically the growth rate of the stimulated Brillouin scattering at higher values of the electron number density of the semiconductor plasma and the wave number of the electron-acoustic wave in the semiconductor. © *2009 American Institute of Physics*. [DOI: 10.1063/1.3050340]

I. INTRODUCTION

The nonlinear interaction of large-amplitude electromagnetic waves in metals, semimetals, and semiconductors has been a great interest in the past several decades.[1–6] Microwave techniques are employed for diagnostics of density of doping concentration and other optical properties and measurements. Large-amplitude electromagnetic waves are used for various nonlinear semiconductor optical device technologies. A particular nonlinear interaction known as the stimulated Brillouin scattering of large-amplitude laser radiation from gaseous and semiconductor plasmas has been studied in detail in the literature.[7–10] However, in all these studies, quantum mechanical effects were not taken into account.

In recent years, there has been a growing interest on the quantum mechanical effects in plasma physics.[11–16] For a supercooled Fermi plasma, the de Broglie wavelengths of the plasma particles may be comparable to the Debye length or other scale lengths of the plasma. Using the magnetohydrodynamic model for the plasmas, Haas,[17] Manfredi,[18] and Marklund and Shukla[19] developed the quantum-hydrodynamic (QHD) model of quantum plasmas.

In this paper, we investigate in detail the stimulated Brillouin scattering of a high-power laser radiation off an electron-acoustic wave in an unmagnetized n-type piezoelectric semiconductor, viz., n-InSb, by employing the QHD model for the electron dynamics in the semiconductor plasma. In Sec. II, we first derive the linear response of electrons in the presence of high-frequency electromagnetic waves in the semiconductor. In Sec. III, we derive the nonlinear dispersion relation of the low-frequency electrostatic electron-acoustic wave in the piezoelectric semiconductor. The nonlinearity arises due to the interaction of the high-frequency electromagnetic incident and the generated sideband waves. The growth rates of the three-wave parametric instability, that is, the stimulated Brillouin scattering including the quantum effects on electrons, average collision, and Fermi temperature effect, have been obtained in Sec. IV. Numerical results and graphical representations are presented in Sec. V. Finally, a brief conclusion is given in Sec. VI.

II. LINEAR RESPONSE

We consider the propagation of a large amplitude laser radiation in a n-type piezoelectric semiconductor, viz., n-InSb. The electric and magnetic fields of the incident linearly polarized laser radiation are chosen as

$$\mathbf{E}_0 = \hat{\mathbf{x}} E_0 \exp[-i(\omega_0 t - k_0 z)],$$

$$\mathbf{B}_0 = c\mathbf{k}_0 \times \mathbf{E}_0/\omega_0,$$

$$\mathbf{k_0} = (\omega_0/c)\sqrt{1-\omega_{pe}^2/\omega_0^2}, \tag{1}$$

where ω_0 and $\mathbf{k}_0$ are the angular frequency and wave number and $\omega_{pe}=(4\pi e^2 n_{e0}/m)^{1/2}$ is the electron plasma frequency. Here, $-e$, m, n_{e0}, and c are the electronic charge, effective mass of electrons, equilibrium electron density, and velocity of light in a vacuum, respectively. We now assume the presence of a low-frequency electrostatic electron-acoustic wave $(\omega,\mathbf{k})$ in the n-InSb sample. The electromagnetic pump wave $(\omega_0,\mathbf{k}_0)$ interacts with the electrostatic perturbation $(\omega,\mathbf{k})$ and produces a high-frequency electromagnetic sideband $(\omega_1,\mathbf{k}_1)$ satisfying the parametric conditions

$$\omega_0 = \omega + \omega_1,$$

$$\mathbf{k}_0 = \mathbf{k} + \mathbf{k}_1. \tag{2}$$

The linear and nonlinear responses to this three-wave parametric interaction are governed by the following equation of motion and continuity of the QHD,

$$mn_{e0}\left[\frac{\partial}{\partial t} + (\mathbf{v}\cdot\nabla)\right]\mathbf{v} = -en_{e0}\mathbf{E} - \nabla p + \frac{\hbar^2}{4m}\nabla(\nabla^2 n), \tag{3}$$

$$\frac{\partial n}{\partial t} + \nabla\cdot(n\mathbf{v}) = 0, \tag{4}$$

where $p=mV_F^2 n^3/3n_{e0}^2$ is the Fermi pressure[18] and $V_F^2=2k_BT_F/m$ with k_B and T_F being the Boltzmann constant and Fermi temperature of electrons. Let us now find first the linear response of electrons to the high-frequency electro-

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magnetic pump and the sideband waves. Using Eqs. (3) and (4), we obtain the linear response of electrons as

$$\mathbf{v}_{0,1} = \frac{-ie\mathbf{E}_{0,1}}{m\omega_{0,1}} + \frac{\mathbf{k}_{0,1}\cdot\mathbf{v}_{0,1}}{\omega_{0,1}}\frac{\mathbf{k}_{0,1}}{\omega_{0,1}}V_F^2(1+\gamma_e), \tag{5}$$

where

$$\gamma_e = \frac{\hbar^2 k^2}{8mk_B T_{Fe}}, \tag{6}$$

and $\hbar$ is the Planck's constant divided by 2π. We note here that the linearly polarized transverse electromagnetic wave is not affected by the quantum effects. Thus, the pump wave dispersion relation is unaffected by the quantum effect, but the sideband contains this effect. Thus,

$$v_{0x} = \frac{-ieE_0}{m\omega_0}, \quad v_{0y} = v_{0z} = 0. \tag{7}$$

Assuming $\mathbf{k}_1$ in the XZ-plane, without loosing any physical insight and taking $\mathbf{E}_1$ as

$$\mathbf{k}_1 = \hat{\mathbf{x}}k_{1x} + \hat{\mathbf{z}}k_{1z},$$

$$\mathbf{E}_1 = \hat{\mathbf{x}}E_{1x} + \hat{\mathbf{y}}E_{1y} + \hat{\mathbf{z}}E_{1z}, \tag{8}$$

we can obtain

$$v_{1x}\left(1 - \frac{k_{1x}^2 V_F'^2}{\omega_1^2}\right) - v_{1z}\frac{k_{1x}k_{1z}V_F'^2}{\omega_1^2} + \frac{ieE_{1x}}{m\omega_1} = 0, \tag{9}$$

$$v_{1y} = \frac{-ieE_{1y}}{m\omega_1}, \tag{10}$$

$$v_{1z}\left(1 - \frac{k_{1z}^2 V_F'^2}{\omega_1^2}\right) - v_{1x}\frac{k_{1x}k_{1z}V_F'^2}{\omega_1^2} + \frac{ieE_{1z}}{m\omega_1} = 0, \tag{11}$$

where $V_F' = V_F\sqrt{1+\gamma_e}$. Solving Eqs. (9) and (11) simultaneously, one can easily obtain

$$v_{1x} = \frac{-ie/m\omega_1}{1 - k_1^2 V_F'^2/\omega_1^2}\left[\left(1 - \frac{k_{1z}^2 V_F'^2}{\omega_1^2}\right)E_{1x} + \frac{k_{1x}k_{1z}V_F'^2}{\omega_1^2}E_{1z}\right], \tag{12}$$

$$v_{1z} = \frac{-ie/m\omega_1}{1 - k_1^2 V_F'^2/\omega_1^2}\left[\frac{k_{1x}k_{1z}V_F'^2}{\omega_1^2}E_{1x} + \left(1 - \frac{k_{1x}^2 V_F'^2}{\omega_1^2}\right)E_{1z}\right]. \tag{13}$$

III. NONLINEAR DISPERSION RELATION

On account of the nonlinear interaction of the electromagnetic pump wave $(\omega_0, \mathbf{k}_0)$ and the sideband $(\omega_1, \mathbf{k}_1)$ satisfying the parametric conditions [Eq. (2)], we obtain the nonlinear response of the low-frequency electrostatic wave as [using Eqs. (3) and (4)]

$$\mathbf{v} = \frac{ie\phi\mathbf{k}}{mf} + \mathbf{F}_P, \tag{14}$$

where

$$f = \nu_0 - i\omega + ik^2 V_F'^2/\omega, \tag{15}$$

$$\mathbf{F}_P = -\frac{1}{2f}\left[(\mathbf{v}_0\cdot\nabla)\mathbf{v}_1^* + (\mathbf{v}_1^*\cdot\nabla)\mathbf{v}_0 - \frac{\mathbf{v}_0\times\mathbf{B}_1^*}{mc} - \frac{\mathbf{v}_1^*\times\mathbf{B}_0}{mc}\right]. \tag{16}$$

Here, the superscript "*" denotes the complex conjugate of a quantity. Using Eqs. (10), (12), and (13) we simplify components of $\mathbf{F}_P$ as

$$F_{Px} = \frac{ie^2E_0k_{1x}}{2m^2\omega_0\omega_1 f(1 - k_1^2V_F'^2/\omega_1^2)}\left[\left(1 - \frac{k_{1z}^2V_F'^2}{\omega_1^2}\right)E_{1x}^* + \frac{k_{1x}k_{1z}V_F'^2}{\omega_1^2}E_{1z}^*\right], \tag{17}$$

$$F_{Py} = 0, \tag{18}$$

$$F_{Pz} = \frac{ie^2E_0}{2m^2\omega_0\omega_1 f}\left[\frac{k_{1x}}{1 - k_1^2V_F'^2/\omega_1^2}\left\{\frac{k_{1x}k_{1z}V_F'^2}{\omega_1^2}E_{1x}^* + \left(1 - \frac{k_{1x}^2V_F'^2}{\omega_1^2}\right)E_{1z}^*\right\} - \frac{k_0}{1 - k_1^2V_F'^2/\omega_1^2}\times\left\{\left(1 - \frac{k_{1z}^2V_F'^2}{\omega_1^2}\right)E_{1x}^* + \frac{k_{1x}k_{1z}V_F'^2}{\omega_1^2}E_{1z}^*\right\} + (k_{1z}E_{1x}^* - k_{1x}E_{1z}^*)\right]. \tag{19}$$

Using Eq. (14) in the equation of continuity, we obtain the linear and nonlinear density perturbations at $(\omega, \mathbf{k})$ as follows:

$$n^L = \frac{ien_{e0}\phi k^2}{m\omega f}, \tag{20}$$

$$n^{\mathrm{NL}} = \frac{n_{e0}}{\omega}(k_xF_{Px} + k_zF_{Pz}). \tag{21}$$

For the high-frequency electromagnetic sideband, the nonlinear current density is given by

$$\mathbf{J}_1^{\mathrm{NL}}(\omega_1, \mathbf{k}_1) = -n^{L*}e\mathbf{v}_0/2. \tag{22}$$

Using Eqs. (20) and (21) in the Poisson's equation and Eq. (22) in the wave equation $(\omega_1, \mathbf{k}_1)$, we obtain

$$\epsilon\phi = -\frac{4\pi e}{k^2}n^{\mathrm{NL}}, \tag{23}$$

$$\underline{\underline{D}}_1\cdot\mathbf{E}_1 = \frac{4\pi i\omega_1}{c^2}\mathbf{J}_1^{\mathrm{NL}}, \tag{24}$$

where

$$\underline{\underline{D}}_1 = \left(k_1^2 - \frac{\omega_1^2}{c^2}\epsilon_1\right)\underline{\underline{I}} - \mathbf{k}_1\mathbf{k}_1, \tag{25}$$

and $\underline{\underline{I}}$ is the unit tensor of rank 2. In Eq. (23), the linear dielectric function of the low-frequency electrostatic electron-acoustic wave taking into account the quantum effect, thermal effects, collisions, and electron-phonon coupling in n-InSb is given by[5,6,20]

$$\epsilon(\omega,\mathbf{k}) = \epsilon_L + \frac{i\omega_{pe}^2}{\omega(\nu_0 - i\omega + ik^2V_F'^2/\omega)} - \frac{K^2k^2C_s^2}{\omega^2 - k^2C_s^2}, \quad (26)$$

where ϵ_L is the lattice dielectric constant, C_s is the ion-acoustic velocity, and K is the dimensionless electromechanical coupling coefficient. The numerical value of K^2 for most of piezoelectric semiconductors[5,6,20] is $\sim 10^{-3}$.

Due to electron pressure (i.e., T_e), an electric field is generated in the piezoelectric semiconductor n-InSb. This electric field produces a phonon wave in the vibrating lattice ions. Now, since the electrons are coupled to the phonons via this electric field, an electron-acoustic-type wave is generated in the electron plasma of the semiconductor due to its own pressure. This electrostatic electron wave is known as the electron-phonon acoustic wave or simply the electron-acoustic wave in n-InSb.

Solving Eq. (24), we obtain

$$\mathbf{E}_1 = \frac{\underline{\underline{R}} \cdot \hat{x}\beta}{|\underline{\underline{D}}_1|}, \quad (27)$$

where

$$\beta = \frac{ie\omega_{pe}^2\phi^* E_0 k^2 \omega_1}{2mc^2\omega_0\omega f^*}, \quad (28)$$

$$|\underline{\underline{D}}_1| = -\frac{\omega_1^2}{c^2}\left(1 - \frac{\omega_{pe}^2}{\omega_1^2}\right)\left\{k_1^2 - \frac{\omega_1^2}{c^2}\left(1 - \frac{\omega_{pe}^2}{\omega_1^2}\right)\right\}^2, \quad (29)$$

and

$$\underline{\underline{R}} = \begin{pmatrix} \left\{k_1^2 - \frac{\omega_1^2}{c^2}\epsilon_1\right\}\left\{k_{1x}^2 - \frac{\omega_1^2}{c^2}\epsilon_1\right\} & 0 & k_{1x}k_{1z}\left\{k_1^2 - \frac{\omega_1^2}{c^2}\epsilon_1\right\} \\ 0 & \left\{k_{1x}^2 - \frac{\omega_1^2}{c^2}\epsilon_1\right\}\left\{k_{1z}^2 - \frac{\omega_1^2}{c^2}\epsilon_1\right\} - k_{1x}^2k_{1z}^2 & 0 \\ k_{1x}k_{1z}\left\{k_1^2 - \frac{\omega_1^2}{c^2}\epsilon_1\right\} & 0 & \left\{k_1^2 - \frac{\omega_1^2}{c^2}\epsilon_1\right\}\left\{k_{1z}^2 - \frac{\omega_1^2}{c^2}\epsilon_1\right\} \end{pmatrix}. \quad (30)$$

Substituting E_{1x} and E_{1z} from Eq. (27) into Eq. (23), we obtain the nonlinear dispersion relation of the low-frequency electrostatic electron-acoustic wave as

$$\epsilon = \frac{\mu}{|\underline{\underline{D}}_1|}, \quad (31)$$

where the coupling coefficient is

$$\mu = -\left(\frac{q^2E_0E_0^*}{m^2\omega_0^2c^2}\right)\frac{\omega_{pe}^4}{4\omega^2 f^2\left(1 - \frac{k_1^2V_F'^2}{\omega_1^2}\right)}\left\{\left[k_1^2 - \frac{\omega_1^2}{c^2}\left(1 - \frac{\omega_{pe}^2}{\omega_1^2}\right)\right] \times\left[k_{1x}^2 - \frac{\omega_1^2}{c^2}\left(1 - \frac{\omega_{pe}^2}{\omega_1^2}\right)\right]\left[k_xk_{1x}\left(1 - \frac{k_{1z}^2V_F'^2}{\omega_1^2}\right) + \frac{k_zk_{1z}k_{1x}^2V_F'^2}{\omega_1^2} - k_zk_0\left(1 - \frac{k_{1z}^2V_F'^2}{\omega_1^2}\right) + k_zk_{1z}\left(1 - \frac{k_1^2V_F'^2}{\omega_1^2}\right)\right] + \left\{k_{1x}k_{1z}\left[k_1^2 - \frac{\omega_1^2}{c^2}\left(1 - \frac{\omega_{pe}^2}{\omega_1^2}\right)\right]\right\} \times\left[\frac{k_xk_{1x}^2k_{1z}V_F'^2}{\omega_1^2} + k_zk_{1x}\left(1 - \frac{k_{1x}^2V_F'^2}{\omega_1^2}\right) - \frac{k_0k_{1x}k_zk_{1z}V_F'^2}{\omega_1^2} - k_{1x}k_z\left(1 - \frac{k_1^2V_F'^2}{\omega_1^2}\right)\right]\right\}. \quad (32)$$

IV. GROWTH RATES

We obtain the growth of this three-wave parametric instability including the quantum effect, that is the stimulated Brillouin scattering. We expand $\epsilon(\omega,\mathbf{k})$ and $\underline{\underline{D}}_1(\omega_1,\mathbf{k}_1)$ around the resonant frequencies[21]

$$\omega = \omega + i\gamma,$$

$$\omega_1 = \omega_1 + i\gamma,$$

$$\epsilon(\omega,\mathbf{k}) = \epsilon_r(\omega,\mathbf{k}) + i\gamma\frac{\partial\epsilon_r}{\partial\omega} + i\epsilon_i,$$

$$|\underline{\underline{D}}_1|(\omega_1,\mathbf{k}_1) = |\underline{\underline{D}}_1|_r(\omega_1,\mathbf{k}_1) + i\gamma\frac{\partial|\underline{\underline{D}}_1|_r}{\partial\omega_1} + i|\underline{\underline{D}}_1|_i, \quad (33)$$

where $\gamma \ll \omega$ and the ϵ_i and $|\underline{\underline{D}}_1|_i$ are the imaginary parts of ϵ and $|\underline{\underline{D}}_1|$. At resonance $\epsilon_r=0$ and $|\underline{\underline{D}}_1|_r=0$, and Eq. (31) yields

$$(\gamma + \gamma_L)(\gamma + \gamma_{L1}) \equiv \frac{-\mu}{\frac{\partial\epsilon_r}{\partial\omega}\frac{\partial|\underline{\underline{D}}_1|_r}{\partial\omega_1}} \equiv \gamma_0^2, \quad (34)$$

where the linear damping rates are defined as

$$\gamma_L = -\frac{\epsilon_i}{\partial\epsilon_r/\partial\omega},$$

$$\gamma_{L1} = -\frac{|\underline{\underline{D}}_1|_i}{\partial|\underline{\underline{D}}_1|_r/\partial\omega_1}. \quad (35)$$

Taking $\nu_0 > \omega, kV'_F$, we obtain from Eq. (26)

$$\frac{\partial\epsilon_r}{\partial\omega} = -\frac{2\omega_{pe}^2 k^2 V_F'^2}{\nu_0^2\omega^3} + \frac{2\omega K^2 k^2 C_s^2}{(\omega^2 - k^2 C_s^2)^2} \quad (36)$$

and

$$\gamma_L = -\frac{\omega_{pe}^2}{\nu_0\omega\,\partial\epsilon_r/\partial\omega}. \quad (37)$$

From Eq. (29)

$$\frac{\partial|\underline{\underline{D}}_1|_r}{\partial\omega_1} = -\frac{2\omega_1}{c^2}\left\{k_1^2 - \frac{\omega_1^2}{c^2}\left(1 - \frac{\omega_{pe}^2}{\omega_1^2}\right)\right\} \times\left\{k_1^2 - \frac{3\omega_1^2}{c^2}\left(1 - \frac{\omega_{pe}^2}{\omega_1^2}\right)\right\}. \quad (38)$$

Using Eqs. (32), (36), and (38) in Eq. (34), we obtain the normalized undamped growth rate of this stimulated Brillouin scattering as

$$\frac{\gamma_0^2}{\omega^2} = -\frac{|V_0/c|^2 c^2 \omega_{pe}^4 (\partial\epsilon_r/\partial\omega)^{-1}}{8\nu_0^2\omega_1\omega^4(1 - k_1^2 V_F'^2/\omega_1^2)\left[k_1^2 - \frac{\omega_1^2}{c^2}\left(1 - \frac{\omega_{pe}^2}{\omega_1^2}\right)\right]\left[k_1^2 - \frac{3\omega_1^2}{c^2}\left(1 - \frac{\omega_{pe}^2}{\omega_1^2}\right)\right]} \times\left\{\left[k_1^2 - \frac{\omega_1^2}{c^2}\left(1 - \frac{\omega_{pe}^2}{\omega_1^2}\right)\right]\left[k_{1x}^2 - \frac{\omega_1^2}{c^2}\left(1 - \frac{\omega_{pe}^2}{\omega_1^2}\right)\right]\right.$$
$$\times\left[k_x k_{1x}\left(1 - \frac{k_{1z}^2 V_F'^2}{\omega_1^2}\right) + \frac{k_z k_{1z} k_{1x}^2 V_F'^2}{\omega_1^2} - k_z k_0\left(1 - \frac{k_{1z}^2 V_F'^2}{\omega_1^2}\right) + k_z k_{1z}\left(1 - \frac{k_1^2 V_F'^2}{\omega_1^2}\right)\right] + \left\{k_{1x}k_{1z}\left[k_1^2 - \frac{\omega_1^2}{c^2}\left(1 - \frac{\omega_{pe}^2}{\omega_1^2}\right)\right]\right\}$$
$$\left.\times\left[\frac{k_x k_{1x}^2 k_{1z} V_F'^2}{\omega_1^2} + k_z k_{1x}\left(1 - \frac{k_{1x}^2 V_F'^2}{\omega_1^2}\right) - \frac{k_0 k_{1x} k_z k_{1z} V_F'^2}{\omega_1^2} - k_{1x}k_z\left(1 - \frac{k_1^2 V_F'^2}{\omega_1^2}\right)\right]\right\}. \quad (39)$$

Now, neglecting the damping of the high-frequency sideband ($\gamma_{L1} \simeq 0$), the growth of the stimulated Brillouin scattering in the presence of the damping of the low-frequency electrostatic electron-acoustic wave is obtained from

$$\gamma(\gamma + \gamma_L) = \gamma_0^2,$$

$$\gamma = \frac{(\gamma_L^2 + 4\gamma_0^2)^{1/2} - \gamma_L}{2}. \quad (40)$$

We now normalize γ by ω and make numerical calculations of γ/ω as functions of various parameters of interest in a n-type piezoelectric semiconductor.

V. NUMERICAL RESULTS AND GRAPHICAL REPRESENTATIONS

To have some numerical appreciation of the stimulated Brillouin scattering, we have calculated the growth rate of this parametric instability for the following set of parameters in n-InSb: $\epsilon_L = 18$, $T_{Fe} = 77$ K, $m = 0.014 m_0$ (m_0 is the free electron mass), $\nu_0 = 3.5\times10^{11}$ s^{-1}, $n_{e0} = 10^{20}$ cm^{-3}, $\omega_0 = 1.778\times10^{15}$ s^{-1} (Nd-glass laser), $C_s = 5\times10^5$ cm s^{-1}, $\theta = (0-\pi)$, $k = (10^6 - 10^8)$ cm^{-1}, $K^2 = 10^{-3}$, and $|V_0/c| = 10^{-3} - 10^{-2}$. The results of our calculations are depicted in the form of curves in Figs. 1–3.

Figure 1 shows the variation γ/ω as a function of the angle of scattering θ. It follows that the normalized growth rate of the three-wave parametric instability first increases up to scattering angle $\theta = \pi/2$ and then decreases.

Figures 2 and 3 illustrate the variation in the normalized growth rate, γ/ω as a function of the number density, n_{e0} without and with quantum effect, respectively. It is evident from Fig. 2 that without quantum effect, the normalized overall growth rate decreases with the increase in number density n_{e0} of the semiconductor electrons. On the other hand, including quantum effect, the normalized growth rate increases with the increase in electron number density (Fig. 3).

Figure 4 shows the nature of variation in γ/ω as a function of wave number k. In this case the behavior of the curve is found to be significantly sensitive for the value of k.

VI. CONCLUSION

A large amplitude laser radiation propagating through a n-type piezoelectric semiconductor undergoes a considerable

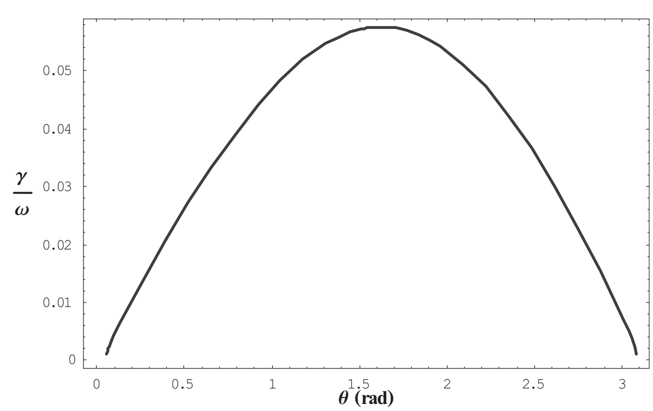

FIG. 1. The variation in γ/ω as a function of the scattering angle θ for the following parameters in n-InSb: $\epsilon_L = 18$ (at 77 K), $n_{e0} = 10^{20}$ cm^{-3}, $m/m_0 = 0.014$, $k = 10^7$ cm^{-1}, $K^2 = 10^{-3}$, $\nu_0 = 3.5\times10^{11}$ s^{-1}, $\omega_0 = 1.778\times10^{15}$ s^{-1}, $C_s = 5\times10^5$ cm s^{-1}, and $|V_0/c| = 10^{-2}$.

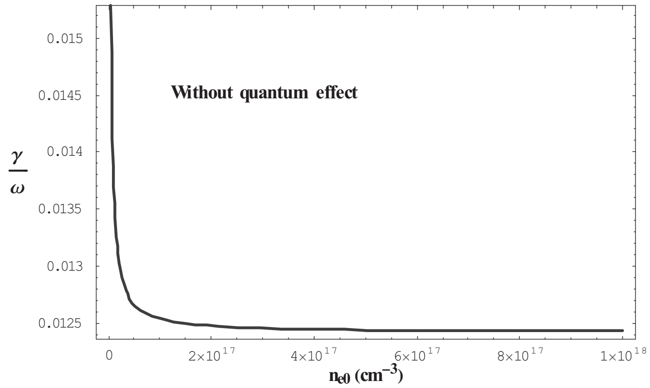

FIG. 2. The variation in γ/ω as a function of the electron number density n_{e0} without quantum effects via Fermi temperature and Bohm potential. Here, $\theta=\pi/4$ and other parameters are the same as in Fig. 1.

Brillouin scattering off the low-frequency and short wavelength electrostatic density perturbation associated with an electron-acoustic wave in the semiconductor plasma. A low-frequency pondermotive force is generated due to the beating of the scattered electromagnetic wave with the incident laser radiation, which then drives the low-frequency electron-acoustic wave. Both the electron-acoustic wave and the scattered sideband grow at the expense of the energy of the pump wave. The quantum effect via the Bohm potential is seen to play a vital role in the scattering process. We find that the Bohm potential in the electron dynamics of the semiconductor plasma enhances drastically the growth rate of the stimulated Brillouin scattering at higher values of the electron number density of the semiconductor and wave number of the electron-acoustic wave. It may be added here that the application of the external static magnetic field in the semiconductor might affect the scattering process and the work in this line is in progress.

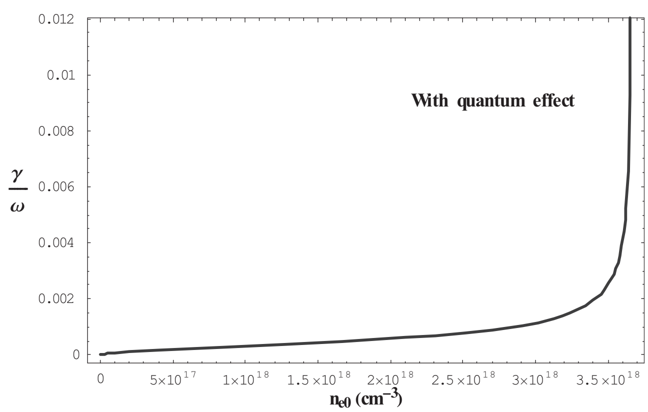

FIG. 3. The variation in γ/ω as a function of the electron number density n_{e0} with parameters as in Fig. 2 with the quantum effect arising through Fermi temperature and Bohm potential.

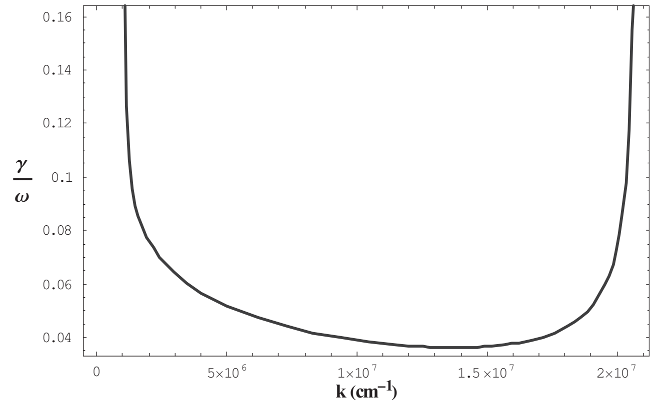

FIG. 4. The variation in γ/ω as a function of the wave number k for $\theta=\pi/4$ and other parameters as in Fig. 1.

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