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► **To cite this version:**

Swati Dubey, S. Ghosh. Stimulated Raman and Brillouin Scattering Processes in Centrosymmetric Semiconductor Plasmas. *Journal de Physique I*, 1997, 7 (11), pp.1445-1453. 10.1051/jp1:1997140 . jpa-00247462

**HAL Id: jpa-00247462**

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Submitted on 4 Feb 2008

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# Stimulated Raman and Brillouin Scattering Processes in Centrosymmetric Semiconductor Plasmas

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(Received 14 February 1996, revised 18 October 1996, received in final form 6 May 1997, accepted 3 July 1997)

PACS.42.65.Dr – Stimulated Raman scattering; CARS

PACS.42.65.Es – Stimulated Brillouin and Rayleigh scattering

PACS.42.50.Md – Optical transient phenomena: quantum beats, photon echo, free-induction decay

**Abstract.** — A simple analytical treatment based on the hydrodynamical model of plasmas is developed to study both steady-state and transient stimulated Raman and Brillouin scattering processes in centrosymmetric or weakly noncentrosymmetric semiconductors. Gain constants, threshold-pump intensities, and optimum pulse durations for the onset of Raman and Brillouin instabilities are estimated. The qualitative behaviour of transient gain factors is found to be in agreement with the experimental and other theoretical observations. The analysis explains satisfactorily the competition between stimulated Raman and Brillouin processes in the short- and long-pulse duration regimes.

## 1. Introduction

Following the advent of lasers, nonlinear optics (NLO) has emerged as a multidisciplinary subject of great breadth and richness, attracting the interest of researchers in basic as well as applied fields. The subject area covered by NLO can be divided into two broad categories: i) steady-state NLO effects, and ii) coherent transient optical effects. A large number of NLO effects (parametric interactions, stimulated scatterings and their applications to parametric amplifiers and oscillators and in phenomena like optical phase conjugation *etc.*) occur as a consequence of either cw laser operation or with lasers having pulse durations much longer than the dephasing or recombination times of the medium. Such NLO phenomena can be broadly defined as steady-state NLO effects. Moreover, sufficiently large interaction times allow the control of light with light and therefore, all optical signal processing phenomena fall into the class of steady-state NLO effects. The origin of such mechanisms in the crystals lies largely in the presence of free-carrier states and the photogeneration of carriers. The study of transient coherent optical effects *viz.*, optical nutation, free induction transparency has become a very important area of research in the recently developed subfield of coherent optical spectroscopy. These effects arise when the material response to an incident intense laser light field is slower than the rate of variation of light intensity. In other words, if the pump pulse duration is much smaller than the dephasing time of the resonant excited state, the medium can keep in memory the light induced coherence for some time after the switching off of the excitation pulse.

Out of the several NLO effects, the nonlinear scattering of laser radiation in gaseous and solid-state plasmas aroused a great deal of interest in the past few years [1–4] on account of the fact that the absorption of laser radiation in plasma greatly depends on these processes. When an intense light beam interacts with an active medium, strong optical amplification of the scattered wave occurs at Stoke's shifted frequency. Such phase coherent processes are called stimulated scattering processes. Amongst these, the study of stimulated Raman (SRS) and Brillouin scatterings (SBS) in solids has been the subject of intensive investigations (both theoretical and experimental) as these have manifest technological applications and provide understanding of the radiation-matter interactions in quantum electronics. An important current application of these processes in modern optics is to generate optical phase conjugation (OPC) in active media [5]. In fact Brillouin and Raman scatterings are fundamentally similar. Each occurs because a nonlinear property of an optical medium couples a mechanical variable (inter atomic distances in molecule, density in a homogeneous solid or liquid) to the charge polarization accompanying an electromagnetic wave. In each, the frequency of an electromagnetic wave is modified by an exchange of energy with the medium in which phonons (acoustical in the case of SBS and optical in SRS) are emitted or absorbed. In spite of such a closeness these phenomena are usually studied independently by considering that the second-order forces responsible for them are different: the finite differential polarizability gives rise to SRS and electrostrictive strain produces SBS in the medium. Quantitative investigations of SBS have clearly shown that the steady-state gain factors are generally one order of magnitude larger than the steady-state gain factors for SRS. It is not surprising, therefore, that SBS competes successfully with SRS in many substances. In fact SRS is strongly suppressed or even extinguished for longer laser pulse while laser light is quantitatively converted into Brillouin light. It is shown by earlier investigations that a time approximately equal to the phonon lifetime is required for the steady-state gain factors of SBS to reach their full values. For times smaller than phonon lifetime, the generation of SBS is greatly reduced and SRS can freely develop. Independent investigations of SRS and SBS steady-state processes using the well known hydrodynamic model and procedure adopted by Guha *et al.* [6] has been made very recently by the present authors [7, 8] (hereafter referred as Papers I and II respectively).

The discussions have so far been restricted to steady-state type solutions [7–9] and in most of the cases workers have assumed monochromatic waves growing in space. Pure temporal growth can be treated in the same manner. The deformation in time of a laser pulse propagating in a medium with an intensity dependent refraction provides an example of a transient nonlinear effect [10]. The study of transient coherent optical effects is an important area of investigation in the realm of coherent optical spectroscopy [11].

The practical utilization of semiconductors in electronics and thorough knowledge of the fundamental properties of these crystals drew the attention of many solid state physicists to examine the role of semiconductors in areas such as spectroscopy, lasers, device fabrications *etc.* Moreover, in the search for optical memories and switching elements, one found that the optical properties of these materials change strongly when electrons are excited optically. The electrical properties of semiconductors lie in between those of metals with nearly free electrons and insulators with tightly bound electrons. This intermediate situation makes semiconductors attractive as nonlinear devices in electronics as well optics because their properties can be influenced easily by fields, compositions and microstructuring. Hence, the supremacy of semiconductors as active media in laser communication, modern optoelectronic devices, optical computing [12–14] and in all optical signal processing [15] is unquestionable and hence the understanding of the mechanisms of transient effects in these crystals appears to be of fundamental significance.

Moreover in contrast with the experimentally predicted large steady-state Raman gain, it is found that it gets almost washed out whereas Brillouin gain attains a large value when the pulse duration of the incident laser radiation  $\tau_p \geq 10^{-9}$  s [16]. Pulse propagation in a resonant medium can yield many interesting phenomena. Transient SRS has been applied to the study of relaxation of material excitations in the picosecond regions with mode-locked laser pulses [16, 17]. Pulsed lasers are often used in stimulated scattering experiments. One must therefore consider the time dependence of the output *i.e.* transient solutions of the SRS and SBS processes in crystals irradiated by pulsed laser.

In solids, particularly in semiconductors, transient coherent optical effects have potential applications in a wide range of areas from optical computing and information storage to the study of hot carrier dynamics and intra band carrier-carrier scattering processes [14]. The coherent transient processes occur typically on subpico- to pico-second time scales and remained unresolved due to the unavailability of laser sources with pulse durations shorter than the above scales. Now with experimentally available short-pulsed lasers having subpico- to femto-second pulse durations [15], the situation has changed such that the time resolved detection of coherent transient effects like optical nutation, free induction decay and self induced transparency is possible in semiconductors with very high spectral and time resolutions [16]. As far as authors know, an attempt to develop a simple analytical treatment based on the hydrodynamic model of plasmas has yet to be made to understand the transient stimulated Raman and Brillouin scattering processes and competition between them in centrosymmetric or weakly noncentrosymmetric semiconductors. The stimulus for the present investigation stems from the above discussions.

Thus in the present communication, the authors report the analytical results obtained while studying SRS and SBS of an hybrid pump wave propagating obliquely in a magnetoactive centrosymmetric or weakly noncentrosymmetric semiconductor plasma. The analysis presented here is based on the consideration that the origin of nonlinear optical properties lies in the third-order nonlinear optical susceptibility of the active medium. Using the coupled-mode theory of plasmas, the steady-state gain constants for both SRS and SBS are obtained analytically. The transient Raman and Brillouin gains *via* corresponding steady-state gains are derived. Numerical estimations of threshold pump intensities and optimum pulse durations have been made with a set of data appropriate for a centrosymmetric or weakly noncentrosymmetric semiconductor crystal duly irradiated by a frequency doubles 10.6  $\mu\text{m}$  CO<sub>2</sub> laser to establish the validity of the present work.

## 2. Theoretical Formulations

This section deals with the theoretical formulation of transient gains (Raman and Brillouin) with the help of corresponding steady-state gain constants. We consider the hydrodynamic model of a homogeneous n-type semiconductor plasma with electrons as carriers subjected to a pump field under thermal equilibrium. In order to study the competition between stimulated Raman scattering (SRS) and stimulated Brillouin scattering (SBS), we consider the propagation of a hybrid pump wave

$$\mathbf{E}_0 = [E_{0x}\hat{\mathbf{x}} + E_{0y}\hat{\mathbf{y}}] \exp[i(k_0x - \omega_0t)], \quad (1)$$

in a homogeneous semiconductor plasma embedded in an external magnetostatic field  $\mathbf{B}_s$  in a direction making an angle  $\theta$  with the  $x$ -axis (the field configuration is the same as given in Papers I and II).

The authors have chosen this particular field geometry because most of the reported cases correspond to the propagation of a pump wave exactly parallel to the applied magnetic field.

Such an exact parallel propagation may not be experimentally feasible. Moreover, the electric field of the pump considered is either perpendicular or parallel to the propagation directions. This, again, is not the case in realistic situations [18]. For a finite solid state plasma  $E_0$  must have components that are both parallel and perpendicular to the propagation direction. Thus the most realistic case (that the authors have considered here) is to consider a hybrid mode propagating obliquely to the external magnetic field.

We apply the coupled mode scheme to obtain simplified expressions for steady-state and transient gains. For the same configuration we have already reported the expressions derived for steady-state gain coefficients of stimulated Brillouin ( $g_B$ ) and Raman ( $g_R$ ) scattering phenomena in Papers I and II respectively.

Thus, following equation (21) of Paper I, one may write the steady-state Brillouin gain coefficient ( $g_B$ ) as

$$g_B = \frac{-\gamma^2 k_s}{4\rho\varepsilon_0\varepsilon_1\omega_a\Gamma_a} \left[ \frac{k_0 - k_a}{k_a} + \frac{\bar{\omega}_p^2}{\omega_0\omega_s} \right] |k_a (E_e)_x|^2 \quad (2)$$

Here  $\mathbf{E}_e = \mathbf{E}_0 + \mathbf{v}_0 \times \mathbf{B}_s$  in which  $\mathbf{v}_0$  and  $\mathbf{B}_s$  are the oscillatory fluid velocity of the electrons and static magnetic field respectively.  $\bar{\omega}_p^2 = \omega_p^2 (\omega_{cx}^2 + \nu^2) / (\omega_c^2 + \nu^2)$  in which  $\omega_{cx}$  is the  $x$ -component of cyclotron frequency  $\omega_c$  and  $\omega_p$  is the electron plasma frequency of the medium. As we are interested in the first Stoke's component of the scattered electromagnetic mode, the phase matching conditions satisfied in deriving equation (2) are  $\omega_s = \omega_0 - \omega_a$ ,  $\mathbf{k}_s = \mathbf{k}_0 - \mathbf{k}_a$ . Here  $(\omega_a, \mathbf{k}_a)$  and  $(\omega_s, \mathbf{k}_s)$  represent the generated acoustic and Stoke's mode, respectively. The order of magnitudes of wave numbers  $k_0$  and  $k_a$  are  $10^5$  m and  $10^7$  m respectively; thus the backward scattering becomes obvious.  $\Gamma_a$  is the phenomenological damping parameter.  $\rho$ ,  $\varepsilon_0$  and  $\varepsilon_1$  are the mass density, absolute permittivity and relative dielectric constant of the crystal respectively.  $\gamma$  is the electrostrictive coefficient of the medium.

Similarly following equations (17, 24) of Paper II, we can write the steady-state Raman gain coefficient ( $g_R$ ) as

$$\begin{aligned} g_R = & \left[ \varepsilon_0\omega_s |(E_e)_x|^2 / \eta c\omega_0^2 m^2 \right] \left[ e^2 (k_0 - k) k\nu\omega_0 \right] \\ & \times (\delta_2^4 + \omega^2\Gamma^2) - \omega_0^2\omega m^2\Gamma(\varepsilon N/2M)(\partial\alpha/\partial u)_0^2 (\delta_1^2 + \omega_s^2\nu^2) \\ & \times \left[ (\delta_1^2\delta_2^2 - \nu\omega_s\omega\Gamma)^2 + (\nu\omega_s\delta_2^2 + \omega\Gamma\delta_1^2)^2 \right]^{-1} \end{aligned} \quad (3)$$

Here  $\delta_1^2 = (\bar{\omega}_R^2 - \omega_s^2)$ ,  $\delta_2^2 = (\bar{\omega}_R^2 - \omega_0^2)$ ,  $\bar{\omega}_R^2 = \omega_R^2 \left[ \frac{\omega_{cx}^2 + \nu^2}{\omega_c^2 + \nu^2} \right]$ ,  $\omega_R^2 = (\omega_p^2\omega_L^2/\omega_T^2)$ ,  $(\omega_L/\omega_T) = \sqrt{(\varepsilon_L/\varepsilon_\infty)}$  in which  $\varepsilon_L$  and  $\varepsilon_\infty$  are the lattice dielectric constant and the high-frequency permittivity of the medium.  $\omega_L$  and  $\omega_T$  are the longitudinal and transverse optical phonon frequencies respectively.  $\eta$ ,  $\nu$  and  $\Gamma$  are the background refractive index, collision frequency and phenomenological damping constant of the medium.

In deriving equation (3) we have considered that the Raman medium consists of  $N$  harmonic oscillators per unit volume each having mass  $M$  which oscillate with the natural mode of vibration within the medium, driven by the optical electric field because of nonvanishing differential polarizability  $(\partial\alpha/\partial u)_0$ .

We can rewrite the above expressions of steady-state gain coefficients in terms of input pump intensity for weakly noncentrosymmetric semiconductor plasma (*viz.*, n-InSb) as

$$g_R \approx 2.067 \times 10^{-8} I_{in}, \quad (4)$$

and

$$g_B \approx 1.52 \times 10^{-4} I_{in}, \quad (5)$$

where  $I_{\text{in}} = (1/2)\eta\epsilon_0c|E_e|^2$  in  $\text{Wm}^{-1}$  and gains are in  $\text{m}^{-1}$ . The relevant physical parameters are obtained from Papers I and II.

From equation (4, 5) one may infer that a high-power laser source is the only pump which yields significant gain constants for both SRS and SRS. Hence the laser pump source should be either in the pulsed form with a time duration of the order of  $10^{-9}$  s for the Q-switched lasers or in the form of pulse-train with the individual pulse duration of the order of  $10^{-12}$  s for mode-locked lasers. Since these time durations are comparable to or smaller than the phonon life times (for acoustical phonon  $\geq 10^{-9}$  s and for optical photon  $\geq 10^{-12}$  s) [18], the study of transient effect becomes important. On the other hand the above formulations are very much handicapped not only in predicting the threshold pump intensity ( $I_{\text{pth}}$ ) correctly for the onset of either SRS or SRS with positive gains, but also in predicting the optimum pulse durations for which these instabilities can be observed. This reveals that SRS and SRS should be treated by incorporating transient effects. In general, following Wang [18], the transient gain factors are related to the steady-state gain coefficients through the following relation

$$g_{\text{TR,B}} = [2g_{\text{R,B}}x\Gamma_{\text{R,B}}\tau_p]^{1/2} - \Gamma_{\text{R,B}}\tau_p, \quad (6)$$

with  $\Gamma_{\text{R}}$  ( $\Gamma_{\text{B}}$ ) being the damping constants of the Raman (Brillouin) wave,  $x$  is the interaction length,  $\tau_p$  is the pulse duration.

The interaction length becomes very small for background scattering because the Stoke's pulse and the laser pulse travel in opposite directions, their overlap region cannot exceed the length of the laser pulse, which for picosecond pump pulses are of the order of a fraction of a millimeter. Thus following Wang [19; pp. 466-467], for very short pulse durations ( $\tau_p \leq 10^{-10}$  s) the interaction length should be replaced by  $(c_1\tau_p/2)$ , where  $c_1$  is the velocity of light in the crystal lattice.

Consequently by making  $g_{\text{TR,B}} = 0$  in the above equation, we can obtain the threshold-pump intensity for the onset of SRS and SRS as

$$(I_{\text{pth}})_{\text{R,B}} = \frac{\Gamma_{\text{R,B}}}{2G_{\text{R,B}}c_1}, \quad (7)$$

with  $G_{\text{R,B}} = g_{\text{R,B}}/I_{\text{in}}$ , the gain per unit pump intensity.

However, for comparatively long pulse-duration ( $\tau_p \geq 10^{-9}$  s), the cell length can be taken equal to  $x$ , and under such circumstances one finds

$$g_{\text{TR,B}} = (\Gamma_{\text{R,B}}\tau_p)^{1/2} \left[ -(\Gamma_{\text{R,B}}\tau_p)^{1/2} + (g_{\text{R,B}}x)^{1/2} \right]. \quad (8)$$

Using the above equation, we may get the idea about the optimum pulse duration  $(\tau_p)_{\text{opt}}$  above which no gain could be achieved by making  $g_{\text{TR,B}} = 0$ , which yields

$$(\tau_{\text{p,opt}})_{\text{R,B}} \approx (g_{\text{R,B}}/\Gamma_{\text{R,B}}). \quad (9)$$

### 3. Results and Discussions

In order to establish the validity of the present model and to study the competition between SRS and SRS processes, we have chosen a weakly noncentrosymmetric crystal (n-InSb) as the medium which is assumed to be irradiated by a pump wave of frequency  $\omega_0 = 1.78 \times 10^{14} \text{ s}^{-1}$ . The physical parameters taken are:  $m = 0.015 m_0$ ;  $m_0$  being the rest mass of an electron,  $\rho = 5.8 \times 10^3 \text{ kg m}^{-3}$ ,  $\epsilon_L = 17.8$ ,  $\epsilon_\infty = 15.68$ ,  $\nu = 3.5 \times 10^{11} \text{ s}^{-1}$ ,  $n_e = 10^{23} \text{ m}^{-3}$ ,  $N = 1.48 \times 10^{28} \text{ m}^{-3}$ ,  $\omega_T = 3.7 \times 10^{13} \text{ s}^{-1}$ ,  $(\partial\alpha/\partial u)_0 = 1.68 \times 10^{-16} \text{ mks units}$ ,  $M = 236.47$ ,  $\gamma = 5 \times 10^{-10} \text{ F m}^{-1}$  and  $\Gamma_a = 2 \times 10^{10} \text{ s}^{-1}$ .

Equations (4, 5) can be used to estimate the ratio ( $g_R/g_B$ ) between the steady-state gain coefficients for SRS and SBS in terms of material parameters. Thus for the same value of pump-intensity  $I_{in}$ , one has

$$(g_R/g_B) \approx 1.36 \times 10^{-4} \quad (10)$$

Equation (10) which yields the ratio of the SRS and SBS steady-state gain coefficients under the same pump intensity indicates that SBS exhibits higher steady-state gain than SRS by a magnitude of the order of  $\omega_T/\omega_a$ , where  $\omega_T$  is the transverse optical-phonon frequency and  $\omega_a$  the acoustical-phonon frequency. This result is in conformity with those obtained with semiclassical theory by Sen and Sen [20] and with coupled mode theory by Neogi *et al.* [9].

The effect of the magnetostatic field  $B_s$  on Raman and Brillouin gains can be studied from equations (2, 3) and are found for the chosen parameters as

$$\frac{(g_B)_{B_s \neq 0}}{(g_B)_{B_s = 0}} \approx 5 \times 10^2, \quad (11a)$$

and

$$\frac{(g_R)_{B_s \neq 0}}{(g_R)_{B_s = 0}} \approx 10^2, \quad (11b)$$

at  $k = 10^7 \text{ m}^{-1}$ ,  $E_e = 10^7 \text{ V m}^{-1}$  with  $\omega_c = 0.9\omega_0$  which is inclined at an angle  $\theta = 45^\circ$ .

It is found from equations (11) that magnetic field enhances the Raman and Brillouin gains.

Using  $\Gamma_R = 3.7 \times 10^{11} \text{ s}^{-1}$ ,  $\Gamma_B = 2 \times 10^{10} \text{ s}^{-1}$  and equations (4-7), one may obtain the threshold values of the pump-intensity for the onset of Raman and Brillouin instability as  $1.26 \times 10^{11}$  and  $10^6 \text{ Wm}^{-2}$ , respectively. The presence of a magnetic field reduces the threshold intensity for the onset of both the processes. The well established fact that the Brillouin instability occurs at much lower pump-intensity than that necessary for Raman instability is confirmed once again by the above estimations.

From equation (9) one may obtain the numerical estimation of optimum pulse duration  $(\tau_p)_{opt}$  for weakly noncentrosymmetric crystal (n-InSb) using the values of  $g_{R,B}$  obtained earlier and  $x = 10^{-4} \text{ m}$  as

$$(\tau_{p,opt})_R = (5.59 \times 10^{-20} I_{in}) \text{ s} \quad (12)$$

and

$$(\tau_{p,opt})_B = (7.6 \times 10^{-15} I_{in}) \text{ s}. \quad (13)$$

The values of  $\tau_{p,opt}$  suggest that optimum pulse duration can be increased by increasing the pump-intensity. Equation (12) explains the washing out of Raman gain at large pulse durations.

The authors shall now address themselves to the question of the behaviour of the transient gain factors  $g_{TR,B}$  as functions of different physical parameters. Figure 1 represents the qualitative dependence of transient Raman ( $g_{TR}$ ) and Brillouin ( $g_{TB}$ ) gain factors as a function of the externally induced magnetostatic field (in terms of cyclotron frequency  $\omega_c$ ). In this figure curve I represents  $g_{TB}$  whereas curve II represents  $g_{TR}$ .  $g_{TR,B}$  are found to be fairly independent of  $\omega_c$  at a lower magnitude of magnetostatic field  $B_s$ . But as  $\omega_c$  approaches the molecular vibrational or acoustical wave frequency, as the case may be,  $g_{TR,B}$  increases rapidly. Thus a higher magnitude of  $g_{TR,B}$  is obtained at  $\omega_c$  comparable to the pump frequency  $\omega_0$  which is independent of magnetic field. Hence, the stimulated laser may be tuned by operating the magnetic field (cyclotron frequency) around the vibrating photon frequency; a similar result already reported in the case of steady-state gain factors by Neogi *et al.* [9]. In the transversely applied magnetic field configuration [21], it is reported that the magnetic field is effective only when the cyclotron frequency  $\omega_c$  exceeds the vibrational phonon frequency of the scattering

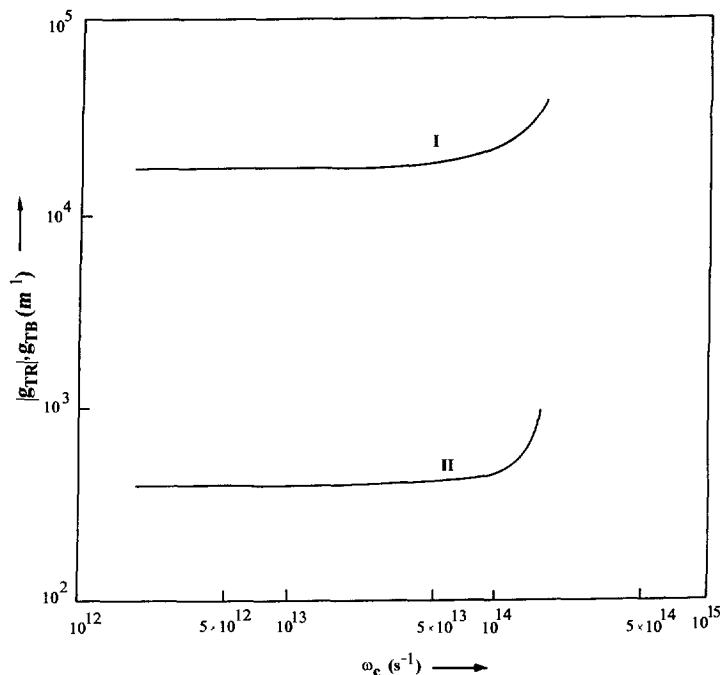


Fig. 1. — Transient gain constants ( $g_{TB}$ ) (curve I) and ( $g_{TR}$ ) (curve II) versus magnetic field (in terms of cyclotron frequency  $\omega_c$ ).

medium. It can be further inferred from Figure 1 that SBS has a larger transient gain as compared to the competing SRS process. This conclusion is in agreement with the investigations carried out by Maier, Wendl and Kaiser [22], where they compared both steady-state and the corresponding transient response of the competing stimulated processes.

Figure 2 shows the variation of transient Raman gain  $g_{TR}$  with steady-state Raman gain  $g_R$  for different pulse durations. For a particular value of  $g_R$ ,  $g_{TR}$  increases with increase in pulse duration. At  $\tau_p = 10^{-2}/\Gamma_R$ , for smaller values of  $g_R$  the transient gain  $g_{TR}$  is found less than 1. For any other pulse duration  $g_{TR}$  is always larger than 1. The qualitative nature of variation illustrated in this figure is in agreement with the experimental results of Carman *et al.* [23].

Figure 3 depicts the qualitative behaviour of the transient gain factors  $g_{TR,B}$  as functions of the pump pulse duration  $\tau_p$  with pump intensity  $I_{in}$  as a parameter. To draw this behaviour, authors have considered pulse durations in the range  $10^{-12} \leq \tau_p \leq 10^{-8}$  s. The interaction length is the cell length  $x$  for SRS while that for backward SBS is  $c_1\tau_p/2$  or  $x$ , whichever is shorter. For fixed  $I_{in}$ ,  $g_{TR}$  increases with pulse duration and at a certain value of  $\tau_p$ ,  $g_{TR}$  attains a maximum value which remains constant for a certain range of  $\tau_p$ . Such regions can be regarded as quasi-steady states or quasi-saturation regimes. Curves III and IV show that the rise in  $I_{in}$  shifts the gain saturation regime towards higher value of  $\tau_p$ . Keeping  $I_{in}$  fixed, if  $\tau_p$  is chosen beyond the quasi-saturation regime,  $g_{TR}$  diminishes very rapidly. This behaviour is very much similar to experimental observations with  $CS_2$  [24] of the saturation of Raman conversion efficiency which is proportional to the exponential of the gain factor, to a very low value at longer pulse duration. Curves I and II represent the transient Brillouin gain factor



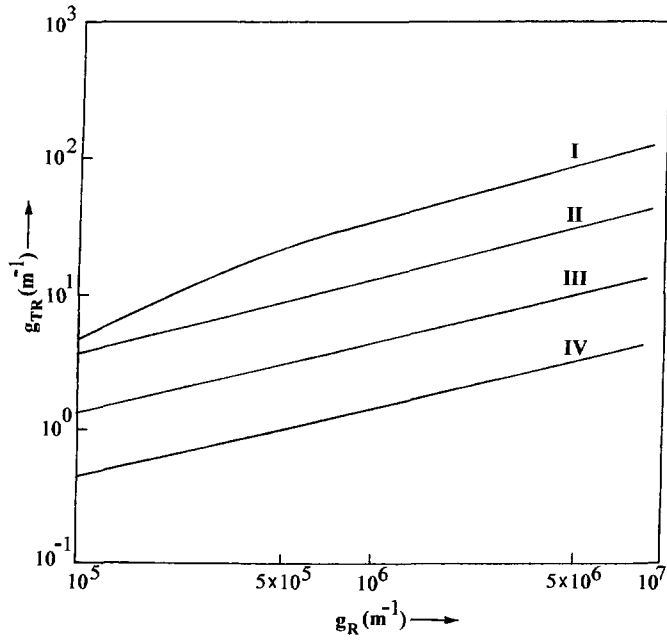


Fig. 2. — Transient gain constants ( $g_{TR}$ ) versus steady-state gain constant ( $g_R$ ) for the SRS process at different pulse durations. Curves I, II, III and IV correspond to  $\Gamma_R \tau_p = 10, 1, 0.1, 0.01$  respectively.

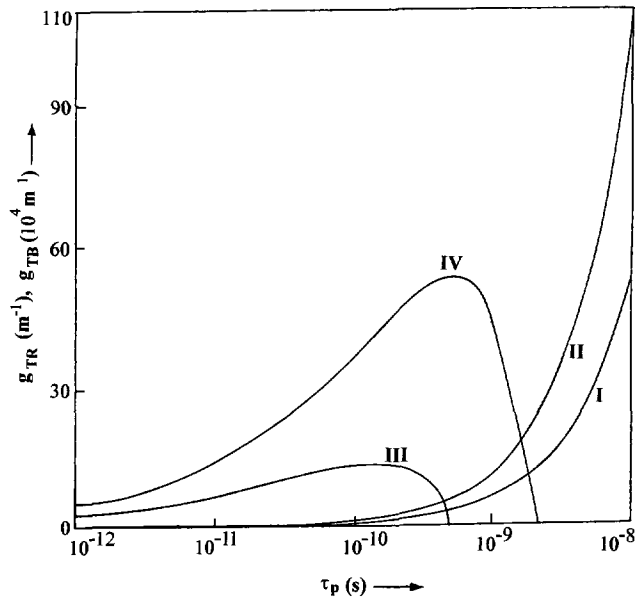


Fig. 3. — Transient gain factor ( $g_{TR,B}$ ) versus pump pulse duration  $\tau_p$  with  $I_m$  as a parameter. Curves I, II correspond to Brillouin gain factors, and III, IV correspond to Raman gain factors. Curves I, III and II, IV are at  $I_m = 1.3 \times 10^{13}$  and  $5.18 \times 10^{13} \text{ Wm}^{-2}$  respectively.

$g_{TB}$  as functions of  $\tau_p$ . For a fixed  $I_{in}$ ,  $g_{TB}$  is found to be vanishingly small at shorter pulse durations with  $\tau_p \leq 0.1$  ns. For further increase in  $\tau_p$ ,  $g_{TB}$  increases very rapidly. We found that for n-InSb  $g_{TB}$  dominates over  $g_{TR}$  for all the possible values of  $\tau_p$ .

The present theory explains satisfactorily the competition between the two transient-stimulated scattering phenomena. The highlight of our theory is that both SRS and SBS (steady-state as well as transient) can be studied in centrosymmetric or weakly noncentrosymmetric dielectrics using a simple classical treatment.

### Acknowledgments

One of us (SD) is thankful to the Council of Scientific and Industrial Research, New Delhi, India for the award of a Senior Research Fellowship.

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