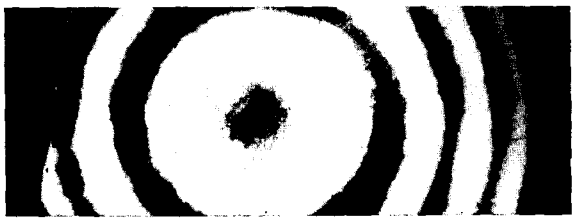

Fig. 1. Interference pattern of emission spectrum of a ruby laser with passive shutter (t = 1 mm).

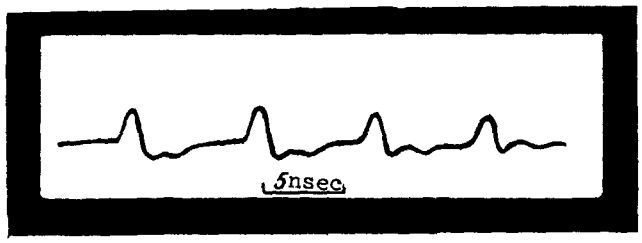


Fig. 2. Time sweep of giant pulse. The oscillogram was retouched in order to improve the contrast.

It must be noted that the pulse duration measured by us, $\tau_p \approx 0.8$ nsec, is apparently determined by the resolution of the recording system*, whereas the limiting pulse duration, at a spectral width $\Delta\nu = 3$ cm$^{-1}$ and under the condition that all the axial modes of the investigated spectrum are synchronized, would amount to $\tau \approx 10^{-11}$ sec, with a corresponding peak power $\sim 2 \times 10^9$ W.

The authors are grateful to S. D. Kaitmazov and I. K. Krasyuk for supplying many of the elements of the apparatus.

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*This is also evidenced by the fact that investigations of self-synchronization in a neodymium-glass laser with a broader emission spectrum ($\Delta\nu = 50 - 80$ cm$^{-1}$) have revealed pulses of the same duration when the same experimental setup was used.

## EXPERIMENTAL INVESTIGATION OF STIMULATED LIGHT SCATTERING IN THE WING OF THE RAYLEIGH LINE

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Submitted 3 May 1967
ZhETF Pis'ma 6, No. 2, 505-509 (15 July 1967)

A powerful light beam of a giant ruby-laser pulse propagating through a medium consisting of anisotropic molecules gives rise to stimulated scattering of light in the wing of the Rayleigh line (SRWS) [1].

A theory [2] developed for plane waves shows that if the Stokes and anti-Stokes components of the scattered light do not interact, then the anti-Stokes component in SRWS is attenuated, and the Stokes component increases, when the threshold indicated in [1,2] is exceeded, in accordance with an exponential law with a coefficient [2]

$$g = -2K_\omega + A|K_1||E_0|^2 \frac{\Omega\tau}{1+\Omega^2\tau^2}, \qquad (1)$$

where $A = \varepsilon_2/2\,\varepsilon_0$ is a constant for any given substance [2], $\vec{K}_1$ is the wave vector of the

scattered light, $\tau$ is the effective anisotropy relaxation time [3], $\Omega$ is the frequency reckoned from the frequency of the exciting light, and $2K_\omega$ is the light absorption coefficient. It follows from the foregoing formula or from the expression for the threshold [1] that in SRWS the maximum amplification coefficient of the Stokes wing of the Rayleigh line will take place at a frequency $(\omega_1)_{max} = \omega_0 - 1/\tau$, where $\omega_0$ is the frequency of the exciting light.

At small scattering angles, the laser emission and the Stokes and anti-Stokes components of the scattered light can interact (four-photon interaction) in such a way that, at a certain optimal angle, both the Stokes and the anti-Stokes components are amplified, the maximum gain occurring in this case at $\Omega = 0$ [2, 4].

We have observed in this investigation, for the first time, the SRWS phenomenon in benzaldehyde, o-xylol, quinoline, nitrotoluene, and acetophenone. The investigation of SRWS in some of these liquids, and also in nitrobenzene [1], was carried out at different temperatures and under different light-propagation conditions in the scattering medium and in the ruby laser.

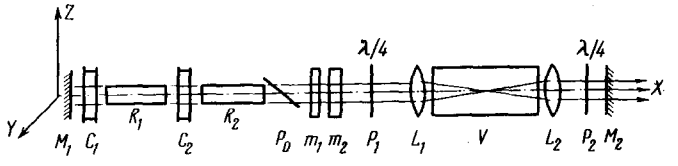


Fig. 1. Experimental setup. $M_1$, $M_2$ - mirrors with R ∿ 100% and R ∿ 50% respectively; $R_1$, $R_2$ - ruby rods; $C_1$, $C_2$ - cells with saturable filters; $P_0$ - glass plate mounted at Brewster angle; $m_1$,$m_2$ - mode separator; $P_1$, $P_2$ - quarter-wave plates; $L_1$, $L_2$ - lenses; V - vessel with investigated liquid.

Our experimental setup is shown in Fig. 1. The ruby-laser power was ∿100 MW and the pulse duration 10 - 15 nsec. The light of the ruby-laser pulse was focused by a lens (f = 5 - 18 cm) inside the vessel with the scattering liquid.

The components of the stimulated Mandel'shtam-Brillouin scattering (SMBS) interfere with the observation of the SRWS spectrum, and special measures were taken to suppress them. The plate $P_1(\lambda/4)$, a polarizer, or a glass plate at the Brewster angle ($P_0$) made it possible to attenuate the sequential scattering process (the back-scattered light). In spite of these measures, two SMBS components remained in the scattered-light spectrum of most liquids. The appearance of a second* SMBS component is apparently caused to a considerable degree by secondary scattering in the region of nonlinear interaction between the light waves and the hypersound waves. In this scattering, the light wave which is back-scattered and shifted in frequency by $\Omega_M$ produces, without going outside the interaction region, a new light wave with frequency shifted by $2\Omega_M$, propagating in the direction of the initial exciting light. The realization of such a scattering mechanism was confirmed by our experiments, in which the scattering volume was located 30 m away from the laser, so that successive scattering with intensification of each succeeding component in the laser was impossible, but two SMBS components were observed all the same.

To intensify in the laser the light of the forward-scattered SRWS, we included in the setup (Fig.1), in addition to $P_0$ and $P_1$, also the plate $P_2(\lambda/4)$ and the mirror $M_2$. There was

no essential difference between the SRWS obtained for one and the same liquid when all the elements of the setup of Fig. 1 were used or when $P_2$ and $M_2$ or $P_0$, $P_1$, $P_2$, and $M_2$ were removed. No anti-Stokes part of the wing was observed under the described experimental conditions, and consequently no four-photon interaction was observed in the wing in the frequency region $\Delta\nu > 0.1$ cm$^{-1}$ (at $f > 5$ cm)**

Intense Stokes SRWS was observed in all the investigated liquids (Fig. 2). The region occupied by the SRWS spectrum increased smoothly with increasing temperature. Thus, the region occupied by the wing increased for nitrobenzene from 1.2 to 3 cm$^{-1}$ when the temperature was raised from 20 to 120°C, and for benzaldehyde it changed from 1 to 2.2 cm$^{-1}$ in the 20 - 100°C interval. Such a variation in the width of the SRWS spectrum is natural, for an increase in the temperature decreases $\tau$ and, according to (1), the maximum of the gain shifts to the Stokes side of the exciting line. Of all the liquids investigated, only nitrobenzene revealed a smeared maximum located, at room temperature, $\sim$0.5 cm$^{-1}$ away from the unshifted line. In all other liquids the maximum, if it does exist, is masked by the ever-present SMBS components. It is also possible that the absence of a pronounced maximum in the SRWS is due to the fact that when the gain g is sufficiently large to observe the SRWS at the given apparatus sensitivity, the field $E_0$ is so strong that the condition for the applicability of the theory [1,2] is not satisfied ($(\alpha_1 - \alpha_2/KT)|E_0|^2 \ll 1$, where $\alpha_1$ and $\alpha_2 = \alpha_3$ are the principal polarizabilities of the molecule).

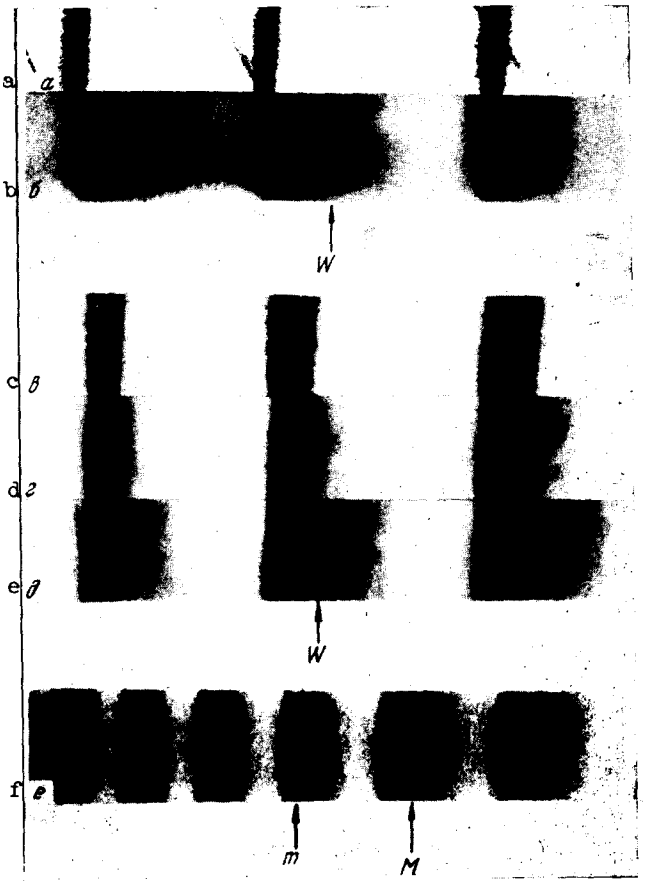


Fig. 2. Stimulated Rayleigh wing scattering spectra. a - Laser emission line ($\lambda$ = 6943); b - SRWS in o-xylol at 20°C; c,d,e - SRWS in nitrobenzene at 20, 65, and 120°C, respectively; f - SMBS spectrum (M) and intensified ruby laser emission mode (m). The Fabry-Perot interferometer dispersion is 5 cm$^{-1}$ for Figs. a - e and 1 cm$^{-1}$ for Fig. f.

The gradual attenuation of the flux of the exciting laser light leads to a rapid decrease in the SRWS intensity, and to its eventual disappearance. Sometimes (o-xylol) several Mandel'shtam-Brillouin components appear at the location of the Stokes wing when the exciting light is attenuated, and consequently a suppression of the SMBS phenomenon occurs when SRWS is produced, at leaset for some liquids.

The scattered-light spectrograms have revealed earlier*** [1,5] and in the present investigation a narrow and rather intense line, which could not be attributed to either SMBS or SRWS

(Fig. 2f). This line was not observed in the spectrum of the exciting line. Its distance to the unshifted line was 0.09 - 0.13 $cm^{-1}$ at room temperature and increased slightly with rising temperature. The intensity of this line was strong enough to produce sometimes a SMBS component. When the exciting light flux was reduced to a value at which a broad section of the SRWS spectrum vanished, this sharp line still remained. It was further established that this line is a weak laser-emission mode,**** which becomes stronger in a medium with anisotropic molecules, by a mechanism which is practically the same as in SRWS. A similar effect was apparently observed recently by Cho et al. [6], who took it to be SRWS. The temperature dependence which they observed for the position of this line may be due to the temperature dependence of the gain and to a mechanism analogous to that indicated by Brewer for SMBS.


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*The first SMBS component may appear in the scattered-light spectrum as a result of reflection from the vessel windows, ruby end faces, etc.

**When the laser emission was focused with a lens of f = 2.5 cm, we observed in nitrobenzene and o-xylol both the Stokes and anti-Stokes parts of the wing in several orders of the interference patterns, and only the Stokes wing in the remaining orders. We assume that in this case we observed four-photon interaction with SRWS at angles $\theta < 2^\circ$.

***This line can be seen in Fig. 1 of [5] between the exciting line and the SMBS component.

****When the distance between the laser resonator surfaces is changed by a factor 1.5, the distance between this line and the main mode of emission changes by the same factor.

## NONLINEAR DEFOCUSING OF LASER BEAMS


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Submitted 4 May 1967
ZhETF Pis'ma 6, No. 2, 509-513 (15 July 1967)


1. We report in this letter the results of a theoretical and experimental investigation of the phenomenon of nonlinear defocusing (principal attention was paid to the steady-state operation) of cw laser beams in liquids. This phenomenon is ocnnected with the dependence of the refractive index on the intensity of the optical field, which is of the form $n = n_0 + n_2|E^2|$. Low-inertia nonlinearity mechanisms with $n_2 > 0$ lead to self-focusing of powerful short pulses [1,2]. For cw lasers, inertial mechanisms are significant, primarily heating of the medium. For this mechanism usually $n_2 < 0$ and defocusing of the beam results; some data on this effect are reported in [6], where it was investigated in an He-Ne laser, and in [7], where only the registration of the effect is reported.