nfluence of nonmonochromaticity of the pump on :he gain of monochromatic Stokes radiation

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Direct measurements were made of the SRS gain at different statistical properties of the amplified signal and of the exciting radiation. The presence of a "critical intensity" and of its dependence on the pump line width is demonstrated. A broadening of the spectrum of a monochromatic Stokes signal in the course of amplification was observed.

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1. Raman scattering in a nonmonochromatic pump field has many interesting :eatures. Its behavior depends on the ratio of such parameters as the width of :he spontaneous Raman-scattering lines and of the pump, the length of the ac- :ive region, the length of the coherent interaction, and the intensity. The nanifestations of all these features are different for different SRS regimes, such as lasing, amplification of an external signal, scattering per pass, etc. Iowever, many of these regimes have been little investigated. Analogously, n the theoretical analysis of the growth rate of the enhancement of the Stokes vave in a broad-band pump field it is customarily assumed that a mono- :hromatic Stokes signal is amplified.[1] In the experiments performed to late,[2,3] however, the conclusions concerning the values of the indicated growth rates were based on indirect measurements of the characteristics of :he SRS initiated by the spontaneous noise inside the active medium. In a known lirect experiment [4], the pumping of a Raman laser (to obtain an external sig- ıal) and amplifier was effected by the same broadband laser. Therefore the statistical properties of the pump and of the Stokes signal coincided.

2. We report here the results of direct experiments on the amplification of a narrow-band Stokes signal in a broad-band pump field. A block diagram of the experimental setup is shown in Fig. 1. The pump sources were two syn- chronized neodymium-glass lasers, I and II, *Q*-switched with Kerr cell, each of which could be locked by the radiation of a narrow-band master laser oper- ating in the free-running regime.[5] In the regime without locking, the lasers generated pulses of spectral width $\Delta\nu_p = 16$ cm^{-1}, as against $\Delta\nu_p < 0.1$ cm^{-1} in the locked regime. In addition, the spectrum of the laser in the regime without locking could be narrowed down to $\Delta\nu_p = 8$ cm^{-1} by introducing a Lyot filter into its resonator. The active medium was SF_6 liquified at 30 atm with a vibrational shift $\Omega = 775$ cm^{-1} and a spontaneous Raman scattering line width $\Delta\nu_L = 1$ cm^{-1}, measured with an *LR*-600 Raman laser spectrometer.

The emission of Laser I, with spectral width $\Delta\nu_p \gg \Delta\nu_L$, served as the pump in the amplifying cell *C*-I. The emission of Laser II, operating in the locked regime, was used as the pump to obtain the narrow band Stokes signal ($\Delta\nu_S \approx \Delta\nu_p < 0.1$ cm^{-1}). This Stokes radiation was introduced into amplifying cell

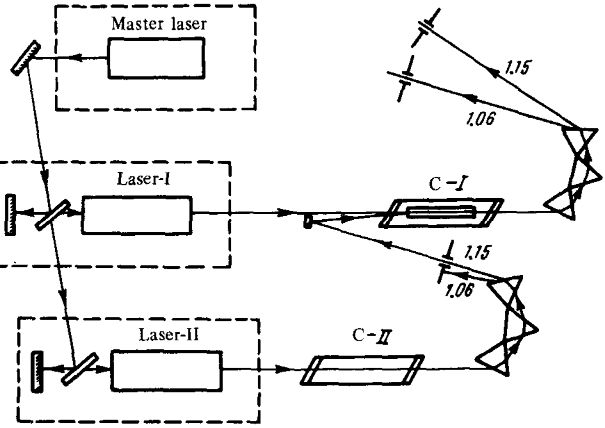

Fig. 1. Diagram of experimental setup.

C-I at an angle $\theta = 5 \cdot 10^{-3}$ rad to the pump-radiation direction. To increase th interaction length of the indicated beams, a metallic light pipe of 4×4 mm cross section and 90 cm length was installed in the cell (see Fig. 1). In the course of the experiments we measured the energies $E_{in}^{(S)}$ and $E_{out}^{(S)}$ of the inpu and output Stokes signals, and also of the pump pulses. A multiple-beam osci loscope 6LOR-02 was used to register the waveforms of the corresponding pulses and to monitor the synchronization of the entry of the pump pulses and of the Stokes signal into the amplifying cell. The pump spectra ($\lambda_p = 1.06$ μ) o the Stokes radiation ($\lambda_S = 1.15$ μ) were registered with an STE-1 spectrograp at second-harmonic frequency.

3. We measured initially the gain under a monochromatic pumping. To this end, the outputs of both lasers were locked by the master-laser radiation. T monochromatic gain turned out to be $g_0 = (5 \pm 1) \cdot 10^{-4}$ cm/MW.

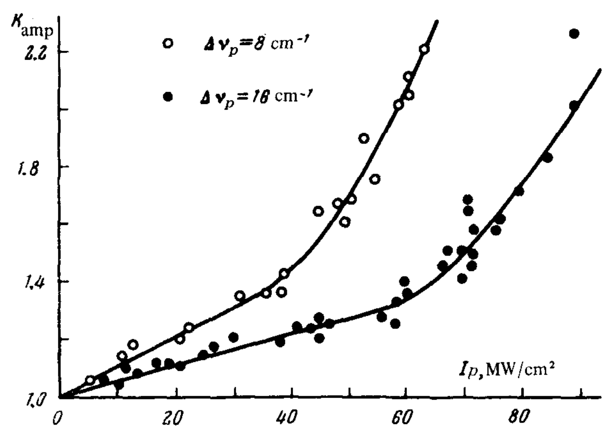

Fig. 2. Dependence of the gain of the monochromatic Stokes signal on the broadband pump intensity.

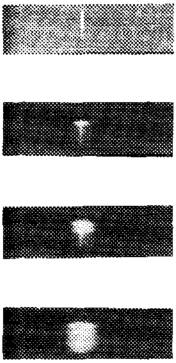

Fig. 3. Spectra of amplified Stokes signal at different pump intensities: a) $I_p < I_{cr}$; b) $I_p \approx 1.5 I_{cr}$; c) $I_p \approx 2I_{cr}$; d) $I_p \approx 3I_{cr}$.

he initial sections of the obtained experimental plots of the gain of the ıan amplifier $K_{amp} = E_{out}^{(S)}/E_{in}^{(S)}$ against the non-monochromatic pump intenare shown in Fig. 2. As indicated above, the measurements were perned for $\Delta\nu_p = 16$ cm^{-1} and 8 cm^{-1} at $\Delta\nu_S < 0.1$ cm^{-1}.

n analysis of the gain curves, with account taken of the time dependence of pump pulses and of the Stokes signal, shows that in the initial section, the wth-rate ratio Γ/Γ_0 is equal, apart from a coefficient 1.5–2, to the ratio $/\Delta\nu_p$ of the line widths. Here $\Gamma_0 = g_0\bar{I}_p$ (cm^{-1}) is the growth rate for the equient monochromatic pump and Γ is the growth rate for the nonmonochromatic ıp. The ratio Γ/Γ_0 is approximately constant up to a certain critical value he intensity of the exciting radiation and begins to increase with further inase of the pump. The bends on the gain curves of Fig. 2 correspond to the ical intensity, the value of which is proportional to the line width. At I_p $_{cr}$, the growth rate Γ approaches Γ_0.

n important feature of the gain at $I_p > I_{cr}$ is the sharp broadening of the ces-signal line leaving the amplifier, to the value $\Delta\nu_p$. Figure 3 shows ctrograms of the output Stokes signal for different pump intensities.

. Thus, the experiments have demonstrated directly the presence of a ical intensity and its dependence on the pump line width. However, an apciable broadening of the spectrum of the enhanced Stokes signal at $I_p > I_{cr}$ l apparently not permit, under real conditions, to transform effectively the ire power of the broadband exciting radiation into a narrow-band amplified ıal.

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