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EXCITATION OF SRS USING A LOW-POWER LASER[1]

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It is known that placement of a Raman-active substance inside a laser
resonator makes it possible to greatly reduce the laser threshold power both
as a result of formation of a resonator for the emission of stimulated Raman
scattering (SRS) and as a result of the large laser-radiation fluxes inside
the resonator [1, 2]. At a given laser power, i.e., the power released by the
working medium of the laser, the laser radiation flux power in the resonator
is determined by the losses introduced by the active element, by the mirrors,
by the optical parts in the resonator, and by the cell with the Raman-active
substance. These losses cannot be made very small. For example, using a ruby
laser, the total loss amounts to 20 - 50% per pass and more. Consequently, in
this case the exciting-radiation power in the resonator is only several times
larger than the laser power.

We propose here a method for exciting SRS, whereby the exciting-radiation
power can be made 100 times the laser power and more. The method is based on
excitation of SRS in a confocal resonator of short length placed inside the
laser resonator and filled with the Raman-active substance. Generation in the
laser resonator is accompanied by much stronger radiation in the interior of
the confocal resonator. In conjunction with the high Q of the confocal resona-
tor for the radiation of the first Stokes component, this ensures excitation
of SRS at relatively low power of the exciting laser[2].

Figure 1 shows a diagram of the experimental setup with a confocal resona-
tor, used to excite SRS in methane. Here 1 and 9 - mirrors forming a ruby-
laser resonator 150 cm long, 2 - ruby rod, 6, 7 - mirrors of confocal resona-
tor of 22 mm radius, 4 - cell with methane at a pressure of 70 atm, 5, 8 - cell
windows, 3 - beam-splitting glass plate. The confocal-resonator mirror re-
flection coefficient was 90% at the laser wavelength and 96% at the wavelength
8708 Å of the first Stokes component.

If the incident radiation beam cor-
responding to some transverse mode of
the laser, and having a frequency lying
within the resonance band of the con-
focal resonator, is not matched to the
confocal resonator, a two-beam annular
mode is established in the confocal
resonator (see Fig. 2). The radiation
flux $P_2^{\dagger}$ in the confocal resonator is
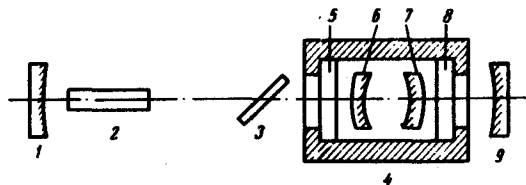connected with the flux $P_1^{\dagger}$ incident on
the resonator by the relation

Fig. 1. Diagram of experimental
setup.

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[2] It is possible to use in lieu of a confocal resonator also a resonator
of the Fox-Smith interferometer type, but in this case it becomes necessary
to match the modes. In addition, it is possible to use different degenerate
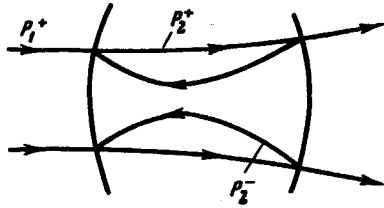resonant systems [3].

Fig. 2. Formation of a two-beam annular mode in a confocal resonator.

$$P_2^+ = m \frac{1-\eta}{(1+\xi)^2} \frac{1}{1-R} P_1^+ , \qquad (1)$$

where $\eta = Q/(1 - R)$, $\xi = \alpha/(1 - R)$, R and Q are the reflection and absorption coefficients of the mirrors at the laser wavelength, α is the loss of laser radiation per pass in the confocal resonator, and m is a coefficient that takes into account the frequency detuning.

It follows from (1) that when $\xi, \eta \ll 1$, $m \sim 1$, and $1 - R \ll 1$ the fluxes inside the confocal resonator, P_2^+ and $P_2^- = RP_2^+$, can exceed the incident flux P_1^+ by many times. The effective reflection coefficient of the system consisting of the confocal resonator and the mirror 9 (see Fig. 1) is

$$R^* = m^2 \left(\frac{1-\eta}{1+\xi} \right)^4 R' , \qquad (2)$$

where R' is the effective reflection coefficient of the mirror 9 with allowance for the losses on the path between the mirror and the resonator. In the described setup, owing to the small length of the confocal resonator compared with the laser resonator and owing to the not too high reflection coefficient of its mirrors at the laser wavelength, the width of the resonance band of the confocal resonator greatly exceeds the distance between the neighboring axial modes of the laser resonator. Lasing should then occur at frequencies close to the center of the resonance band of the confocal resonator and $m \sim 1$.

For the total flux of the exciting radiation (in both directions) we can obtain the expression

$$P_{exc} = \frac{1+R}{1-R} \frac{1}{1+\xi} \frac{P_{gen}}{\kappa + 2(\xi + \eta)} , \qquad (3)$$

where P_{gen} is the laser generation power, κ is the loss coefficient per pass in the laser resonator in the absence of a confocal resonator (at ξ, η, $R = 0$). This value may greatly exceed the power of the exciting radiation without the confocal resonator, $P'_{exc} = P'_{gen}/\kappa$, where P'_{gen} is the generation power in the absence of the confocal resonator, and is close to P_{gen} if the laser operates much above threshold. We note that to reduce the aberrations in the confocal resonator it is desirable to decrease the transverse dimensions of the light beams under its mirrors; this can be done, for example, with the aid of a lens placed ahead of the resonator.

We present below the main experimental results. In practice, at the very threshold of laser generation, we obtained excitation of the first Stokes and first anti-Stokes SRS components. The first Stokes SRS was excited in the form of the fundamental two-beam mode of the confocal resonator. The confocal resonator selected effectively the transverse laser modes, reflecting into the active element of the laser the radiation of practically only the fundamental mode. However, owing to the inhomogeneities of the ruby rod, the dimension of the radiation spot incident on the confocal resonator exceeded the dimension of the spot for the fundamental mode. At the SRS threshold, the laser pulse consisted of 5 - 10 spikes of 0.5 - 1 μsec duration. The radiation of the first Stokes SRS component also consisted of several spikes of 0.1 - 1 μsec

duration. Unlike the laser radiation, the spikes of the Stokes radiation had a characteristic steep front. Estimates of the threshold power gave for the backward flux from the confocal resonator into the ruby rod a value $P_1 \sim 20$ W. When account is taken of the losses in the unbleached optical parts, the effective reflection coefficient was 35%, giving a value ~ 60 W for the incident flux. Actually, the incident power was ~ 130 W, and consequently approximately half of this flux, pertaining mainly to emission of the higher modes, was reflected sideways by the confocal resonator. This can be attributed to the distortion of the mode structure of the radiation in the ruby rod, to the influence of aberrations of the confocal resonator, and to possible inaccuracy in the adjustment.

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INFLUENCE OF ROTATION OF THE SPONTANEOUS-MAGNETIZATION VECTOR ON THE HALL EFFECT

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We wish to point out in this article a new feature of the behavior of the Hall effect in ferro-ferrimagnets, never before discussed in the literature.

An analysis of the experimental results on the Hall effect in these substances leads to the assumption that the rotation of the spontaneous-magnetization vector I_s by an external field H about the crystallographic axes causes the additional contribution to the anomalous Hall field.

Figure 1 shows a plot of the Hall emf E_H against the magnetization I for an alloy of 45% Ni and 55% Fe and for the ferrite $MnFe_2O_4$. The Hall emf and the magnetization were measured by the method described in [1].

We see that in the initial sections of these curves the Hall emf varies practically linearly with the magnetization. At certain values of I this dependence is violated and the increment of the Hall emf for the same magnetization increment becomes smaller. A plateau appears in the $E_H(I)$ curve in a certain interval of magnetization values. With increasing temperature,
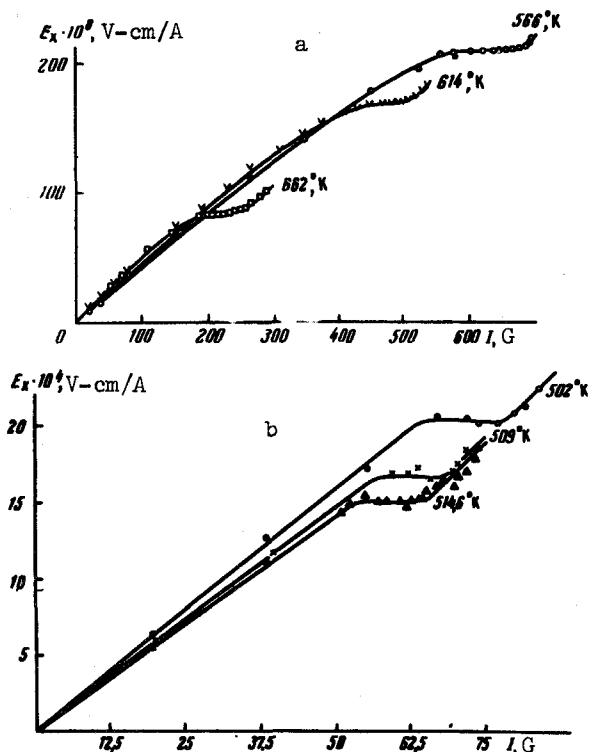

Fig. 1. Dependence of the Hall emf E_H on the magnetization I for an alloy of 45% Ni and 55% Fe (a) and for single-crystal $MnFe_2O_4$ (b).