USP. In such a case, the observed total width of the spectrum will correspond to USP of approximate duration 10^{-14} sec. We arrive at analogous conclusions if we consider the consecutive collinear interaction of AM components, which is described by equations of the Mathieu type with a spectrum of multiple frequencies.

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METHOD OF INCREASING THE EMISSION SPECTRUM WIDTH IN A NEODYMIUM-GLASS LASER WITH A PASSIVE SHUTTER

A.A. Ionin, V.I. Malyshev, and A.V. Masalov
P.N. Lebedev Physics Institute, USSR Academy of Sciences

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Broadening the spectrum in a mode-locked laser is one of the ways of increasing the peak power of the optical emission. Usually, however, to obtain a higher degree of mode locking and to decrease the influence of nonlinear effects in a neodymium laser, one operates at pumps close to threshold. In these cases the generation spectrum width is relatively small, 4 - 6 cm^{-1}, and the spectrum lies near the maximum of the gain contour. Since in the general case the width of the generation spectrum is determined by the Q of the different modes of the resonator and by the width and shape of the gain contour, one can expect, if the mode selection is eliminated, that variation of the shape of the gain contour will also permit variation of the generation spectrum width. We have attempted in this study to control the width of the spectrum in such a manner.

In our experiments, the gain contour was deformed by "burning out" the inverted population and producing a dip in the center of the inhomogeneously broadened luminescence lines of the neodymium ions, and also by migration of the excitation energy from some regions of the active rods to others. Both processes exert a strong influence on the spectral and temporal characteristics of a solid-state laser and determine, in particular, the kinetics of the free-generation spectra of a neodymium-glass laser [1].

To investigate the indicated spatial interaction of the different regions of the active medium, and its influence on the width of the generation spectrum, we used a passive-shutter laser with two generation channels formed in

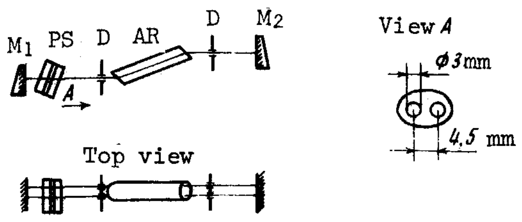

Fig. 1

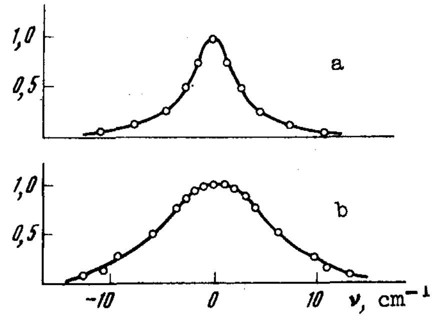

Fig. 2

Fig. 1. Experimental setup: M_1, M_2 - mirrors on wedge-like substrates, with reflection coefficients 1.0 and 0.7, respectively; PS - passive shutter (solution of dye No. 3955 in nitrobenzene with initial transmission 55% and cell thickness 1 mm); D - diaphragms; AR - active rod (LGS-28-2, 12 mm dia, 160 mm long).

Fig. 2. Emission spectra of the first (a) and second (b) channels. The delay between pulses is 50 μsec.

the same neodymium-glass rod with the aid of two-aperture diaphragms (Fig. 1). In such a laser, the generation of giant pulses in each of the channels occurs at different instants of time, and by varying the gains in the channels it is possible to vary the interval between the pulses from several to 200 microseconds. We investigated the spectral and temporal characteristics of the radiation in each of the channels at different delay times between the generation pulses.

The investigations carried out at pumps close to the threshold values have shown that the spectral and temporal characteristics of the radiation of any of the channels, in the case when the other is blocked, do not differ from the characteristics of an ordinary laser with an ordinary shutter, namely the width of the generation spectrum is 4 - 6 cm^{-1}, the spectrum is cut up and has an irregular structure that varies from flash to flash, and the duration of the generation pulse is $\sim$50 nsec. The same can be said also with regard to the emission of the channel in which the generation occurs earlier (arbitrarily called the first channel).

It was observed that the spectral and temporal characteristics of the radiation of the second channel depend on the delay time between the generation pulses. In the case of time delays shorter than 10 μsec and longer than 100 μsec, the emission of the second channel does not differ from that of an ordinary laser. At delays in the range 10 - 100 μsec, appreciable differences are observed in the emission of our laser. Namely, the peak of the spectrum becomes flat (and even takes the form of a dip in some cases) and the width of the spectrum increases by 2 - 3 times to 12 - 15 cm^{-1}, the total laser pulse duration decreases somewhat (to 20 - 30 nsec), and the modulation depth, registered with a resolution 1.5 nsec, decreases. The difference between the shapes of the spectra is clearly seen in Fig. 2.

The observed singularities in the emission spectrum of the second channel can be explained, in our opinion, as follows. The generation pulse of the first channel lifts the inversion in its own channel, and, owing to the inhomogeneous broadening of the luminescence line of the neodymium ions in the glass, a dip is produced near the maximum of the gain line; the width of the dip is close to the homogeneous width of the Nd^{3+} luminescence (the homogeneous width is 20 -

30 cm^{-1} [2][1]). Thus, the equilibrium distribution of the excitation among the different neodymium ions is disturbed in the region of the first channel. The subsequent migration of the excitation washes out the produced dip. Whereas the excitation in the region of the first channel migrates after the lasing mainly within the limits of the luminescence line, from the line wings to its center, and excitation migrates from the peripheral regions into the first channel principally from the ions whose emission lies in the region of the maximum of the luminescence lines. As a result, in the active-medium regions that are peripheral with respect to the first channel, meaning also in the second channel, the inverted population at the maximum is decreased and the effective width of the gain line is increased. This results in a broadening of the generation spectrum.

However, the final width of the emission spectrum of the second channel should depend on the delay time between the lasing, since, in addition to the processes considered above, the initial line contour is restored as a result of the excitation of the neodymium ions by the pump radiation. This means that at sufficiently long delays between the lasing pulses, the broadening of the spectrum ceases, as was observed by us at delays exceeding 100 μsec.

On the other hand, if the delay between the generation pulses is short enough, then the excitation migration has no time to introduce noticeable distortion in the gain contour of the second channel, and the effect will not occur. This is also confirmed experimentally in the case of delays shorter than 10 μsec.

The proposed picture of the phenomenon agrees also with the fact that narrowing of the first-channel spectrum with the aid of the selectors did not change the singularities of the spectrum of the second channel.

As already noted, the irregular structure of the spectrum of the second channel does not duplicate the spectral structure of the first. This indicates that there is no optical coupling between the emission channels, and that the emission of the second channel stems from its own noise. In addition, as shown by investigations with the aid of the two-photon luminescence method [3], the product $c\Delta\nu\Delta t$ for both channels is close to 0.4, where $\Delta\nu$ is the width of the emission spectrum in cm^{-1} and Δt is the correlation time determined by measuring the width of the bright peak in the two-photon luminescence method (the width of the bright peak of the second channel is half that of the first). These measurements show that the broadening of the emission spectrum in the second channel is not connected with any additional phase modulation.

Thus, the use of a two-channel neodymium-glass laser with a passive shutter makes it possible, by suitable choice of the delay time (which is determined by the laser parameters), to increase appreciably the width of the emission spectrum in the mode-locking regime, and by the same token, in principle, to decrease the maximum duration of picosecond pulses.

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