STIMULATED EMISSION OF $LiNbO_3$ CRYSTALS WITH NEODYMIUM IMPURITY

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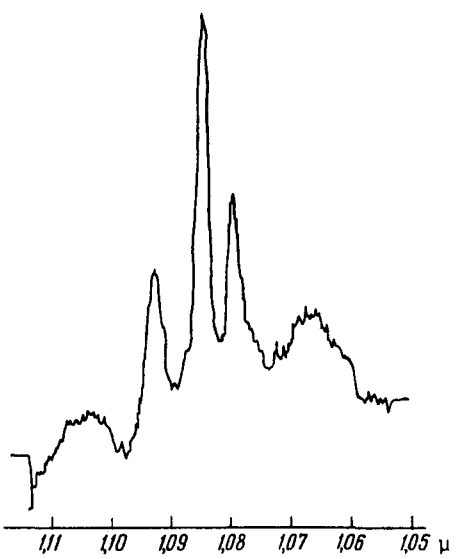
Lithium niobate is a promising material for nonlinear optics. It has been shown that it can be used effectively for modulation and frequency multiplication in the optical band [1-4]. There are no reports of the use of this crystal as a laser active medium. Evidently, the development of a laser with this crystal, which has moreover good electrooptical characteristics, is of interest for many practical applications.

We produced stimulated emission in a lithium niobate crystal containing 1% wt. Nd_2O_3.

The investigated crystals were grown by the Czochralski method from a platinum crucible. The growth conditions ensured a plane crystallization-front surface. The optical quality of the crystals was not high. The sample in which the stimulated emission was produced was 5 mm in diameter and 19 mm long. The polar axis of the crystal was oriented at a right angle to the geometric axis of the sample.

The figure shows the luminescence spectrum of neodymium in the investigated crystals in the region near 1000 nm, taken at room temperature with a DFS-12 spectrograph. The center of the most intense line is near 1085 nm, and its width is 2.0 ± 0.1 nm. The lifetime of the corresponding excited state is 85 ± 5 μsec at room temperature. The centers of the two other less intense lines are near 1079 and 1093 nm.



Stimulated emission in the free pulsed lasing mode was obtained at the most intense luminescence line at room temperature. The generation wavelength was 1084.6 ± 0.1 nm. The excitation threshold was 14 J, and when account is taken of the differences in the crystal lengths and the IFP-800 lamp employed, it amounts to 3.5 J. The generation was observed in a confocal resonator made up of external dielectric mirrors with 500 mm radius of curvature and 99% reflection coefficient. The generation threshold remained practically unchanged when one of the 99% mirrors was replaced with a mirror having 70% reflection, this being due to the poor optical quality of the crystal.

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NONLINEAR FERROMAGNETIC RESONANCE

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We consider a ferromagnetic sample acted upon by both an alternating and a constant magnetic field ($\vec{h}$ and $\vec{H}$, respectively). When the constant magnetic field has a value $H_1 = \omega/\gamma$ (ω - frequency of ac field, γ - gyromagnetic ratio), linear ferromagnetic resonance sets in. The ferromagnetic-resonance (FMR) phenomenon consists in excitation, by an incident photon, of a spin wave having the same energy as the photon. It is obvious that, in addition to this process, a spin wave can be excited with simultaneous absorption of n incident photons, and then the spin-wave energy is n times the photon energy. We shall call such a process nonlinear ferromagnetic resonance (NFMR) of order n. The value of the constant magnetic field, which determines the energy of the spin waves and which is necessary to observe resonance of order n, is obviously $H_n = n\omega/\gamma$.

The probability of production of one spin wave upon absorption of n photons differs from zero in n-th order perturbation theory.

Let us investigate second-order NFMR, i. e., n = 2. The interaction Hamiltonian can be written in the form

$$H = \vec{h}\cdot\vec{M}, \tag{1}$$

where $\vec{M}$ is the magnetization vector of the sample (the direction of the equilibrium magnetization $\vec{M}_0$ coincides with the z axis).

Using the standard procedure, going over from (1) to the second-quantization representation [1], and using second-order perturbation theory, we obtain the following expression for the probability of the production of one spin wave with simultaneous absorption of two photons:

$$W = \frac{\pi\gamma^3 M_0}{4\omega^2} V f(\omega) h_x^2 h_z^2 , \tag{2}$$

where V is the volume of the sample and $f(\omega)$ is the form factor of the line. The power absorbed in the nonlinear resonance is

$$P_{abs} = \chi''_{res} \frac{\gamma^2 h_x^2 h_z^2}{4\omega} V, \tag{3}$$

where χ''_{res} is the resonant susceptibility in linear FMR [2]. According to (2), the NFMR