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STIMULATED EMISSION OF Nd^{3+} *IN* CaF_2 *AT ROOM TEMPERATURE*

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STIMULATED emission in crystals of the fluorite type (CaF_2, SrF_2, and BaF_2) containing Nd^{3+} at room temperature has been observed so far only in the case of SrF_2 [1]. The present communication gives preliminary results of an investigation of stimulated emission from Nd^{3+} in CaF_2 at room temperature. The crystals used were grown from the melt in a fluorine atmosphere by slowly lowering the crucible; the crystals had various concentrations of neodymium oxide. Oscillation was observed in crystals with Nd_2O_3 concentrations of 0.3 and 1.5% and occurred at a wavelength of about 1.047 μ. The electrical energy at threshold in the optical excitation system used was about 190 Joules for a crystal having an Nd_2O_3 concentration of 0.3% (the crystal was 60 mm long and 6.5 mm in diameter).

Excitation of the system is by absorption of light

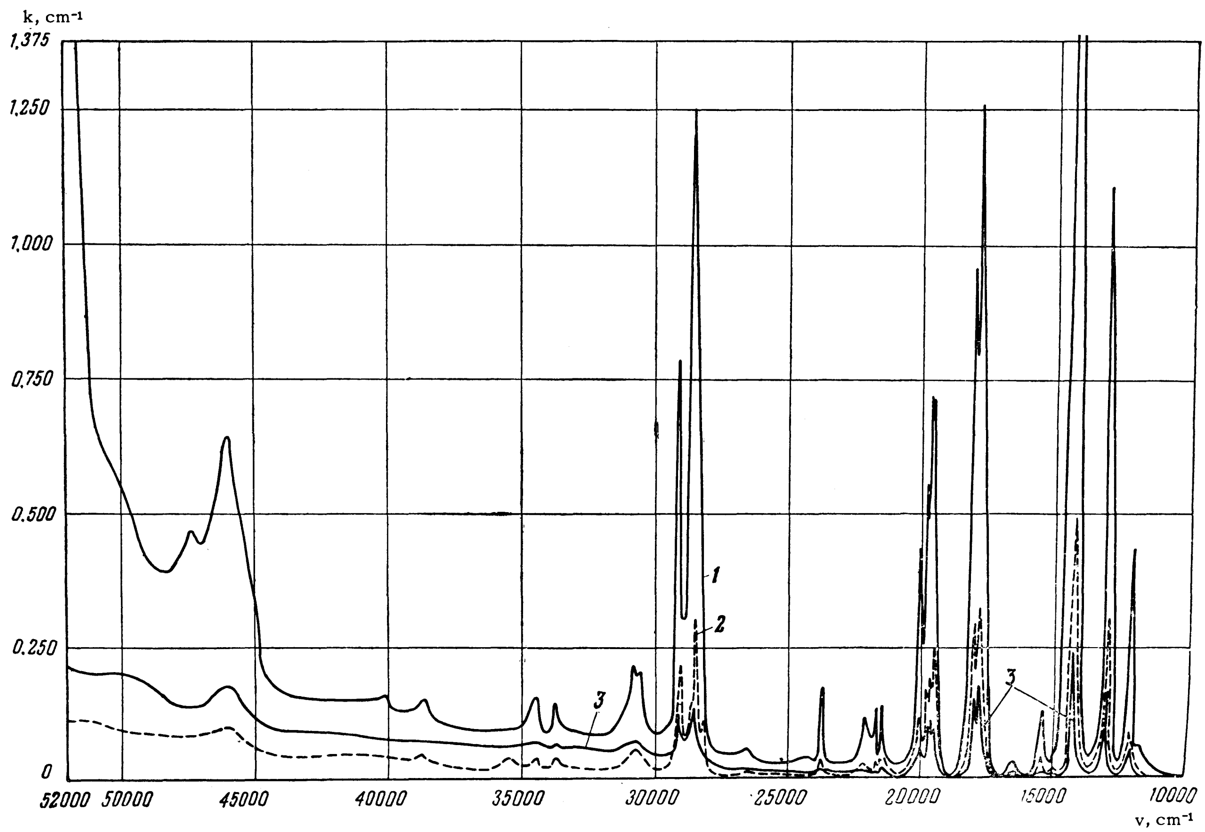

FIG. 1. Absorption spectra of Nd^{3+} in CaF_2 at room temperature for various Nd_2O_3 concentrations; 1 – 0.2%; 2 – 0.5%; 3 – 1.5%.

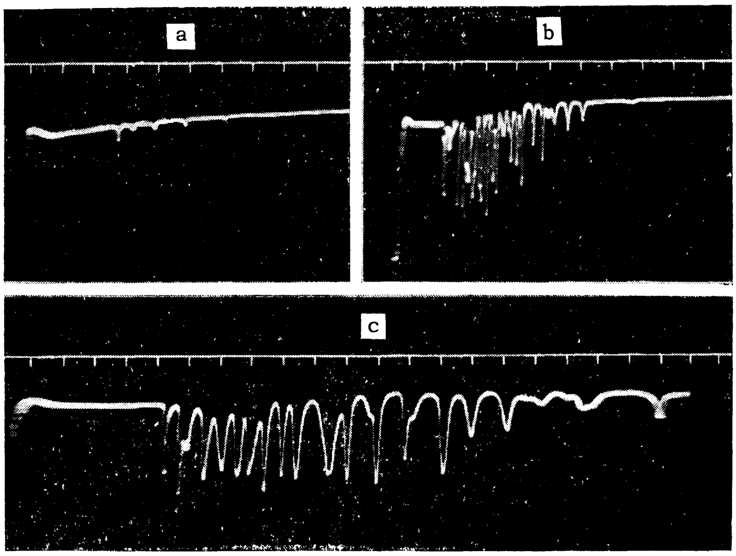

FIG. 2. Oscillograms of the output pulse of Nd^{3+} in CaF_2 at 300°K for various values of the electrical energy input to the flash lamp: a – threshold at 190-joules, output duration ~250 μsec per scale division; b – 720-joules, output duration 450 μsec, 75 μsec per scale division; c – threshold value of 720-joule, output duration 450 μsec, 25 μsec per division.

from a flash lamp in absorption bands lying 14000 cm^{-1} above the ground level. The infrared luminescence of the Nd^{3+} ion in CaF_2 begins on a $^4F_{3/2}$ level and terminates on various levels of the ground multiplet ^4I. The strongest luminescence corresponds to the transition $^4F_{3/2} \rightarrow {}^4I_{11/2}$. It is this line at which oscillation occurs. Figure 1 shows the absorption spectra of Nd^{3+} in CaF_2 at room temperature for three values of the Nd_2O_3 concentration. It is clear from the figure that as the concentration is increased to 1.5%, the intensity of the absorption lines increases linearly without significant broadening. Studies of the paramagnetic resonance spectra of the Nd^{3+} ion in CaF_2[2] indicate that, in the crystals which we used, some of the Nd^{3+} ions are located in a crystalline electric field of tetragonal symmetry and others are in a field of rhombic symmetry; the number of the latter increases as the square of the Nd^{3+} concentration. The number of ions located in a field of trigonal symmetry—a situation which should occur when one of a Nd^{3+} ion's nearest-neighbor fluorines is replaced by an oxygen ion—is small. These sites could not be detected in the paramagnetic resonance studies although an absorption band due to O^{2-} ions at 46,000 cm^{-1} is observed in the optical spectrum.

The apparatus for optical pumping used in the experiments consisted of an elliptical cylinder with the crystal located at one focus and a linear pulsed flash lamp having a luminous length of 80 mm located at the other focus. The crystals used were cylindrical rods with plane polished ends 6.5 mm in diameter and about 6 cm long. The optical cavity was formed by confocal dielectric mirrors with reflection coefficients $\sim 98\%$ at 1.06 μ. The radius of curvature of the mirrors was 500 mm. and their diameter was 40 mm. To observe the time dependence of the output, the beam from the cavity was made to fall on a photomultiplier with an oxygen-cesium photocathode; a silicon filter 1 mm thick was placed at the aperture of the photomultiplier. The photomultiplier signal was displayed on an oscilloscope. Figure 2 shows oscillograms of the output obtained from a crystal with Nd_2O_3 concentration of 0.3% for three values of the electrical input energy to the flash lamp. The pulse is seen to consist of a series of spikes of about 5 μsec duration. At threshold there are 3–5 spikes, and the total duration of the output is about 250 μsec. For energies two to four times the threshold value the output duration increases to 450 μsec.

A grating spectrograph (DFS-13) with a grating of 600 lines/mm was used to study the structure of the output radiation. For the crystal with a neodymium oxide concentration of 0.3% the full line width of the output was about 3 Å, and the line consisted of four fine-structure components. For the crystal with the 1.5% concentration the number of fine structure components increased to twelve and the full line width of the output broadened to 5 Å.

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