I. A. Shcherbakov. *Energy transfer in solids, new active media for solid-state lasers.* The present status of the problem of nonradiative transfer of electronic excitation energy in dielectric crystals and glasses is discussed. It is demonstrated that the theory of static transfer and the theory of hopping quenching of luminescence agree quantitatively with the experimental data on the interaction of rare-earth and transition-element ions in laser crystals. The three-stage nature of the law governing the energy transfer from the donor subsystem into the acceptor subsystem is revealed experimentally. The general laws relating the microscopic mechanisns of interionic interaction with the energy relaxation processes in the group of interacting particles are established. It is shown that rejection of the "τ" approximation and realization of experimental methods for measuring the evolution of the population of the excited states over a large dynamic range will make it possible to determine the microscopic interaction constants and to forecast the spectral-luminescence properties of impurity crystals. The quantitative interrelationship of the evolution of the population in the donor and acceptor subsystems is established. Matrices in which the concentration quenching of luminscence and, in particular, nonradiative losses from the upper laser levels are anomalously weak and proposed; this made it possible to increase substantially the concentration of working particles.

Methods for increasing by more than an order of magnitude the energy density stored in the active medium of a laser were proposed and realized. This effect is achieved by separ-

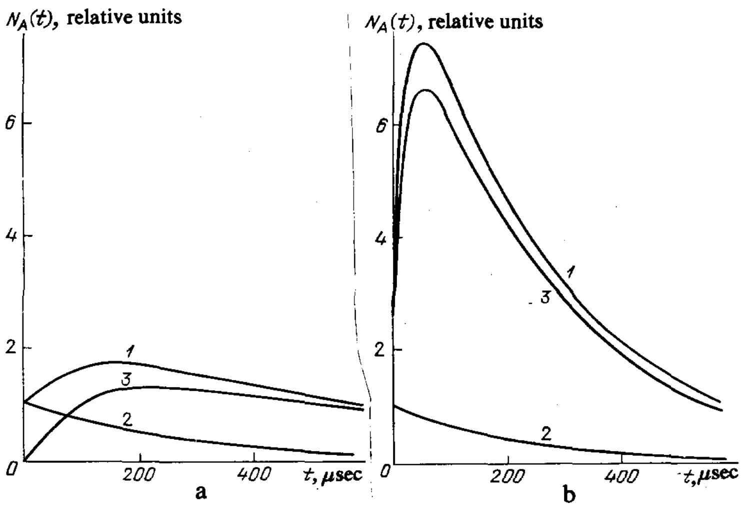
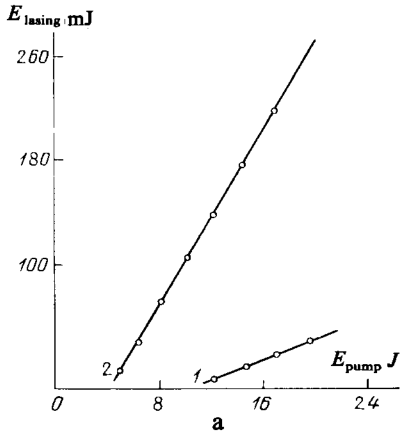


FIG. 1. The population of the upper laser level of Nd^{3+} ions at $T = 300$ K as a function of time $N_a(t)$ in crystals activated by chromium ions; the sample was excited by a δ-pulse of light, whose spectral composition corresponds to the spectral composition of the ISP-1000 lamp. a) YAG crystal with a neodymium concentration of $1 \cdot 10^{20}$ cm^{-3} and a chromium concentration of $1.5 \cdot 10^{20}$ cm^{-3}; b) GSGG crystal with a neodymium concentration of $2 \cdot 10^{20}$ cm^{-3} and a chromium concentration of $3 \cdot 10^{20}$ cm^{-3} (total curve (1)); neodymium ions, excited into their own characteristic absorption bands (2); neodymium ions excited by chromium ions (3)).



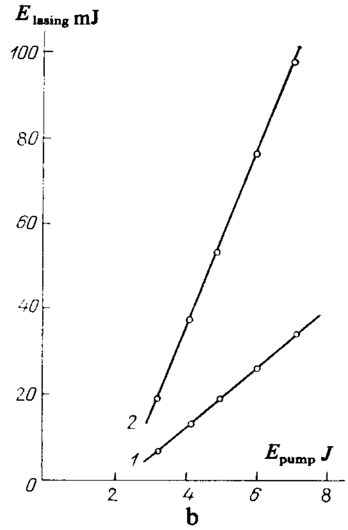


FIG. 2. Comparative lasing characteristics of neodymium ions in SGG and YAG crystals. Lasing on the transition ${}^4F_{3/2} \rightarrow {}^4I_{11/1}$ in neodymium. Free lasing conditions. a) GSGG crystal activated only by neodymium ions (1) and GSGG crystal activated by chromium and neodymium ions (2); b) YAG:Nd^{3+} (1) and GSGG:Cr^{3+}:Nd^{3+} (2) crystals.

ating the functions of the working particles: some particles, which have an intense broadband spectrum, efficiently absorb energy and transfer it rapidly and completely to other types of particles, which efficiently accumulate energy in a metastable state and emit coherently in narrow spectral lines. At the same time, it was possible to realize weak interionic interactions within each of the subsystems and strong interactions between particles belonging to different subsystems.

Figure 1 shows examples of the evolution of the population of the metastable state of neodymium in the well-known yttrium aluminum garnet (YAG) crystal and in the gadolinium-scandium-gallium garnet (GSGG) crystal which we proposed. In both bases, the chromium ions are the energy donors and the neodymium ions are the working particles of the laser. Figure 2 shows the results of the lasing studies. The compositions of the crystals were optimized from the technological viewpoint and also from the viewpoint of their radiative properties. As a result, a new class of crystals was synthesized using standard equipment; in addition, the time of the process cycle was shortened several-fold. Lasers with record-high efficiencies, whose lasing parameters remained constant under gamma irradiation of the active elements up to dosages $\sim 10^7$ rad, have been built based on the crystals developed. High efficiency, technological effectiveness, and high radiation resistance are not the only advantages of the new class of crystals. The study of the fundamental processes involved in the transfer of electronic excitation energy also permits expanding the lasing frequency range, obtaining lasing on new transitions, and, in particular, obtaining smoothly wavelength-tunable lasing in solid-state lasers at room temperature with the use of standard, nonselective, excitation sources. This is achieved by establishing and realizing criteria for rapid and complete energy transfer from the chromium ions to all rare-earth ions of practical interest, by realizing the required electronic-vibrational energy distribution over the excited states of chromium, and by the possibility of lasing on new transitions.

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