A	B	$\Delta E = E_A - E_B$, meV			Note
		K_{α_1}	K_{β_1}	$K_{\beta_{2,4}}$	
SmS $P \ll 5$ kbar	SmS $P \approx 0$	-6 ± 25	-12 ± 46	–	—
SmS $p > 9$ kbar	SmS $P \approx 0$	-319 ± 43	-926 ± 41	-258 ± 180	—
SmF_3	$SmCl_2$	-578 ± 22 -606 ± 19	-1438 ± 56 -1455 ± 50	-293 ± 85 -415 ± 50	Our data Data of [4]
SmF_3	SmS	-595 ± 20	-1430 ± 40	-556 ± 50	—
Sm^{3+}, $4f^5$	Sm^{2+}, $4f^5 5d'$	-62	65	60	HFS calculation
η		0.60 ± 0.08	0.62 ± 0.03	0.42 ± 0.30	—

1) This phenomenon was used in [6] to investigate the mechanism of the low-temperature isomorphic phase transition in cerium.

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EFFECTIVE 1.054 → 1.54 μ STIMULATED EMISSION CONVERSION

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We report here, apparently for the first time, effective conversion of neodymium-laser emission ($\lambda = 1.054$ μ) into stimulated emission in the 1.54 μ band. The conversion was obtained by using the neodymium laser to stimulate emission in ytterbium-erbium glass on the ${}^4I_{13/2}$ - ${}^4I_{15/2}$ transition of the Er^{3+} ions (three-level lasing scheme). The pump radiation is absorbed in this case by the Yb^{3+} ions as a result of an electronic transition between the upper Stark component of the ground level ${}^4F_{3/2}$ and the metastable level ${}^4F_{7/2}$, with subsequent nonradiative transfer of the excitation energy to the Er^{3+} ions (Fig. 1). Although the initial sublevel of the absorptive transition is very weakly populated at room temperature ($\sim 1.5\times10^{-2}n_0$), introduction of very large Yb^{3+} concentrations into the glass (up to 1.5×10^{21} cm^{-3}) guarantees an absorption coefficient on the order of several hundredths of a cm^{-1} at the pump frequency. Such an absorption level, of course, gives rise to high threshold densities of the exciting radiation, but these are obtainable in the neodymium-laser pulses and do not exceed the optical strength of the glass. At the same time, when the absorption is weak it becomes possible to obtain exceptionally uniform excitation of large volumes of the active medium. Our preliminary analysis and spectral-luminescence investigations of the characteristics of Yb^{3+} + Er^{3+} ion systems in various

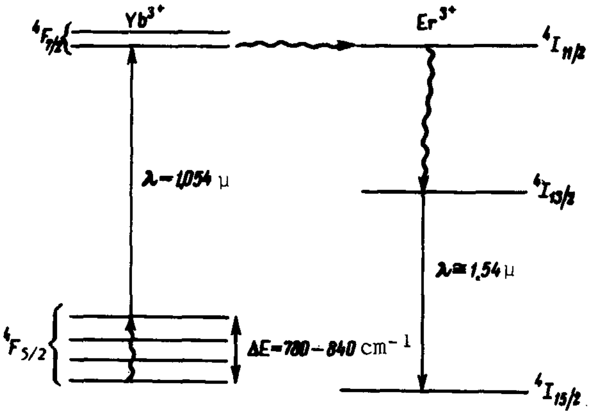

Fig. 1. Simplified scheme of 1.054 → 1.54 μ stimulated-emission conversion.

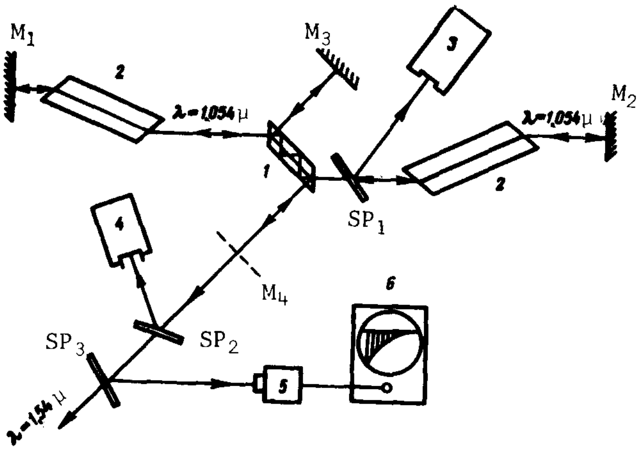

Fig. 2. Optical diagram of the experiment.

glass matrices, including the quantum yield and the singularities of nonradiative transfer in the Yb^{3+} + Er^{3+} pair at high densities of the exciting radiation, have shown that under optimal conditions it is quite realistic to expect an energy conversion efficiency η = 40 - 50%1). In this case, it is possible to develop on the basis of the described scheme systems operating in the 1.54 μ band, with energies only slightly lower than those of pulsed neodymium lasers, and even superior to the latter in some respects, say with respect to divergence angle and radiation brightness. We note by way of comparison that the energy efficiency of the already known erbium-glass lasers [1 - 3] pumped by flash lamps does not exceed 0.3 - 0.5%, and the energy delivered is on the order of tenths of a Joule.

We chose for our lasing studies barium-alumometaphosphate glass activated with 1.5×10^{21} cm^{-3} Yb^{3+} ions and 2.5×10^{19} cm^{-3} Er^{3+} ions, which is superior to other glass matrices in its aggregate of spectral and luminescence characteristics. Its pump-radiation absorption coefficient is 6.2×10^{-2} cm^{-1}, the effective cross section for stimulated emission of the Er^{3+} ions at the generation frequency is 1.2×10^{-20} cm^2, the luminescence duration Er^{3+} is 8.8×10^{-3} sec, and the rate of nonradiative excitation-energy transfer in the Yb^{3+} + Er^{3+} pair is larger than 9×10^3 sec^{-1}, and the quantum transfer efficiency, determined from the shortening of the Yb^{3+} lifetime, exceeds 0.93. This glass was used to prepare an active element in the form of a rectangular plane-parallel plate of cross section 10×14 mm and length 70 mm, with two side faces inclined at an angle 45° ± 5". The pump radiation was introduced into the active element in a direction normal to one of the inclined faces (10×20 mm) and emerged from the opposite face after undergoing several total internal reflections inside the rod. The use of an inclined pump beam made it possible to double the exciting-radiation flux density in the interior of the element, compared with the input radiation density, and to ensure a more uniform distribution of the excitation over the volume of the active medium. Another advantage of using an active element having this shape is that the pump and laser beams can be spatially separated in a simple manner.

The optical diagram of the experiment is shown in Fig. 2. The Yb^{3+} - Er^{3+} element (1) was placed in the resonator of the pumping neodymium laser with base 1200 mm, made up of two dielectric mirrors M$_1$ and M$_2$ with reflection coefficients $r_{1,2}$ = 99.5% and two active elements (2) of LGS-40 phosphate glass, in the form of plates with rectangular cross section 10×32 mm and length 280 mm, with end faces cut at the Brewster angle. The neodymium elements were symmetrically arranged relative to the Yb^{3+} - Er^{3+} element, and as a result the non-uniformity of the excitation along this element did not exceed 2% even though this element, serving as the useful load of the neodymium pump emission. The duration of the neodymium-element excitation pulses was 1.6×10^{-3} sec at the 0.1 level, and their emission wavelength was 1.054 ± 0.001 μ. The energy delivered at the input face of the Yb^{3+} - Er^{3+} element was measured with an IKT-1M calorimeter (3), to which a calibrated fraction of the radiation was diverted with the aid of beam-splitting plate SP$_1$ placed in the resonator. The resonator of the erbium laser was made up of dielectric mirrors M$_3$ and M$_4$ (r_3 = 99%, r_4 = 62%) at a base 150 mm. Its generation energy was measured with a second IKT-1M calorimeter (4). The kinetics of generation development was registered with a germanium photodiode (5) connected to a long-persistence S1-42 oscilloscope (6). The lasing spectra were investigated with a spectrographic having a dispersion 20 Å/mm by burning out the emulsion of a previously exposed and developed photographic film.

The erbium laser generation had a typical spiked character, with individual spikes having durations 1 - 3 μsec. At a slight excess above threshold, the emission was on the $\lambda_1 = 1536$ nm line with $\Delta\lambda_1 = 1.6 - 1.8$ nm, followed in succession by weaker lines with $\lambda_2 = 1543 \pm 1$ nm (1.5 times threshold) and $\lambda_3 = 1538 \pm 0.75$ nm ($\sim$ 2.5 times threshold).

The threshold pump energy was 5.3 J absorbed per cm^3 of the Yb^{3+} - Er^{3+} element. At three times threshold the radiated energy per free-generation pulse was 21 J at a differential conversion coefficient $\eta_d \simeq 29\%$. When Q-switched by a rotating prism (500 rps), the same element emitted 5.1 J in a pulse of $\sim$ 30 nsec duration. The poor optical quality of the glass produced under laboratory condition did not make it possible to tune the erbium-laser generator with accuracy higher than ±1', which is patently insufficient for effective laser operation. With this taken into account, one can hope that glass of better optical quality will make a conversion efficiency $\sim$ 40 - 50% perfectly realistic.

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INCOHERENT $K_L^0 \to K_S^0$ REGENERATION ON ATOMIC ELECTRONS AT HIGH ENERGIES, AND THE ELECTRIC RADIUS OF THE K^0 MESON

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It is noted that the cross section for coherent regeneration of K_S^0 mesons when K_L^0 mesons interact with atomic electrons increases rapidly with increasing K_L^0-meson energy. As a result, at very high energies ($\sim$ 100 GeV), the reaction $K_L^0 + e \to K_S^0 + e$ can be used for an experimental determination of the K^0-meson rms radius, which characterizes the electric-charge distribution. The energy spectrum of the relativistic recoil electrons is considered and numerical estimates are given.

The regeneration of short-lived neutral K mesons (K_S^0) when long-lived neutral K mesons (K_L^0) collide with atomic electrons was discussed earlier by Zel'dovich [1] (see also [2]). The amplitude of this process is expressed directly in terms of the electric radius of the K^0 meson. At energies $E_K < m_K$, the effective regeneration cross section $\sigma(K_L^0 + e \to K_S^0 + e)$ increases rapidly with increasing K-meson laboratory energy. In this connection, at very high energies (> 100 GeV), it becomes possible in practice to determine experimentally the electric radius of the K^0 meson by studying the incoherent regeneration of K_S^0 mesons on atomic electrons[1]. The reaction $K_L^0 + e \to K_S^0 + e$ can be uniquely identified by registering simultaneously the relativistic recoil electrons and the charged pions from the $K_S^0 \to \pi^+\pi^-$ decay.

As is well known, in the Born approximation the differential cross section for elastic scattering of electrons by spinless hadrons is described by the formula (see, e.g., [4]):

$$\frac{d\sigma}{dt} = \frac{\pi \alpha^2}{t_{max}} F^2(t)[(p_a + p_a', p_e + p_e')^2 - t(p_a + p_a')^2]\frac{1}{st^2}. \qquad (1)$$

Here p_a and p_a', p_e and p_e' are the 4-momenta of the hadron and electron before and after scattering, respectively ($p_a^2 = p_a'^2 = m_a^2$, $p_e^2 = p_e'^2 = m_e^2$), $s = (p_a + p_e)^2$, $t = -(p_e - p_e')^2 = -(p_a' - p_a)^2$, $\alpha = e^2/\hbar c$ is the fine-structure constant, F(t) is the hadron electromagnetic form