When precision physical experiments are performed with test bodies, it is essential to take into account the effect of ponderomotive rotational instability. If the body is not free but constitutes a torsional pendulum illuminated by an electromagnetic flux, then the presence of a temperature dependence of the absorption coefficient leads to additional stiffness and friction in the system; their signs and magnitudes depend on the thermal inertial properties of the body.

In conclusion, let us note one interesting circumstance. The angular velocity of a body having the dimensions of the earth would change after 5 billion years, as a result of the foregoing effect, by an amount $\Delta\omega \simeq 2 \times 10^{-5}$ rad/sec (assuming $b(\omega) \simeq 10^{-1}$), under the condition that the flux density of the solar radiation, averaged over 5 billion years, is larger by approximately one order of magnitude than the presently observed value. (At the present time, ω of the earth amounts to 7.3×10^{-5} rad/sec.)

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STRUCTURE OF SPECTRA OF SOLID-STATE LASERS IN THE FREE GENERATION REGIME

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We have observed in an earlier study [1] that the emission spectra of free-generation spikes of solid state lasers without mode selection have an irregular structure. The cause of this structure may be the spatial inhomogeneity of the field in the laser resonator, which leads to an uneven burning out of the inversion [2]. Such a situation obtains in a laser operating in the "standing" wave regime.

To verify the correctness of the assumption that spatial inhomogeneity of the radiation field plays a role in the formation of the irregular structure of the spectra, we have investigated the emission spectra of lasers operating in the "traveling" wave regime. The active elements of the lasers were ruby and neodymium glass, in which, as is well known, the luminescence-line broadening occurs in different ways.

To obtain the "traveling" wave regime, we chose two widely used resonator systems (Fig. 1): a - a ring resonator with a Faraday cell as a nonreciprocal element [3], and b - a ring resonator with a return mirror [4]. The resonator length length was $L \simeq 170$ cm.

The emission spectra in the setup of Fig. 1a were carried for a ruby laser (AR) of 10 mm diameter and 110 mm length. The mode selection in the resonator was eliminated by using nonselective elements. The diaphragms D_1 and D_2, of 2 mm diameter, suppressed the non-axial modes. The spectra were registered with the aid of a Fabry-Perot interferometer (SP) with a resolution $\delta\nu = 0.015$ cm^{-1}. The picture of the spectrum was projected on the input slit of a high-speed scanning camera (SFR) operating in the slit-sweep regime. The reduction of a large number of spectrograms has shown that the spectra of the emission spikes of the described laser always have a structure that is irregular from spike to spike. A typical microphotograph of the spectrum of the first generation spike is shown in Fig. 2a.

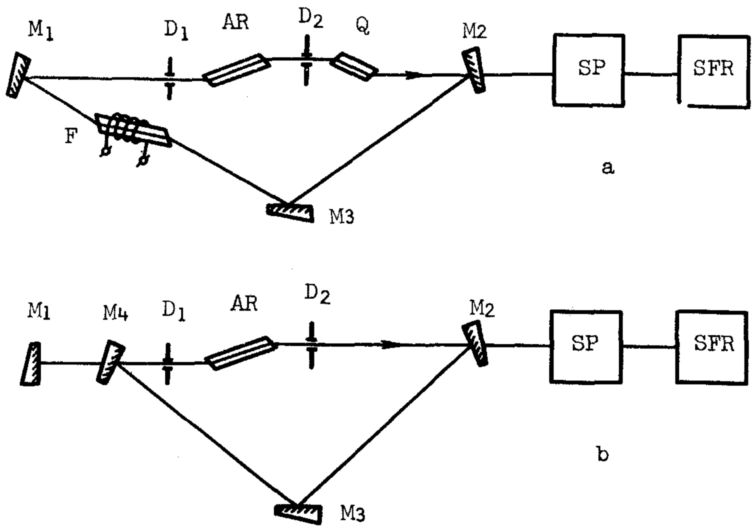

Fig. 1. Diagrams of experimental setups: a - ring resonator with Faraday cell (F), Q - crystalline quartz plate rotating the polarization plate by 45°; b - ring resonator with return mirror M_1. The mirror reflection coefficients are $R_1 = 1.0$, $R_2 = 0.9$, $R_3 = 1.0$, $R_4 = 0.75$.

In the setup of Fig. 1b, where the "traveling" wave regime is realized by means of the mirror M_1, the active elements were ruby (10 mm diameter, 110 mm long) and neodymium glass (10 mm diameter and 130 mm long). The intensity ratio of the forward and backward waves was approximately 50. The spectrum of the neodymium glass laser was registered with a diffraction spectrograph having a resolution $\delta\nu = 0.1\ \text{cm}^{-1}$, and the spectrum was scanned with the aid of the SFR camera. The spectral apparatus for the ruby laser was the same as in Fig. 1a. In this resonator scheme, too, the free-generation spectra of the ruby and neodymium-glass lasers have an irregular structure (Figs. 2b, c), and elimination of the spatial inhomogeneity of the field led only to a change in the kinetics of the spectrum [1, 5].

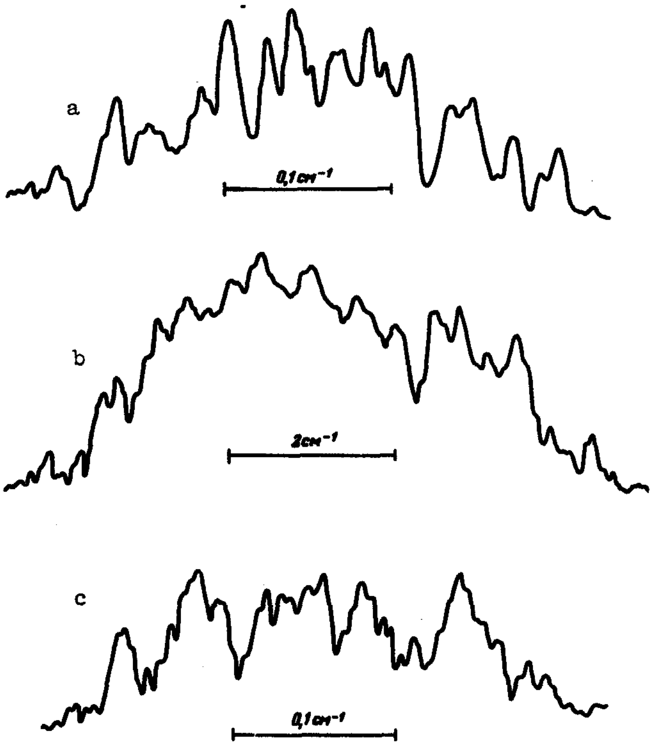

Fig. 2. Microphotographs of spectra of the first spike: a - ruby laser with setup of Fig. 1a; b - neodymium laser with setup of Fig. 1b; c - ruby laser with setup of Fig. 1b.

We have thus shown experimentally that elimination of the selection and of the spatial inhomogeneity of the radiation field of lasers whose active media exhibit different luminescence-line broadening does not eliminate the irregular structure of the free-generation spectra.

To explain the observed irregular structure it is necessary, in our opinion, to take into account the fluctuating character of the laser emission. In accordance with the concept of the fluctuating character of the emission, developed in [6], the laser emission field in the axial period can be regarded as consisting of pulses of identical shape f(t):

$$E(t) = \sum_l a_l f(t - \theta_l)\exp(2\pi i c\nu_0 t + i\phi_l),$$

where the instants of appearance of the pulses θ_j, their relative amplitudes α_j, and their phases ϕ_j are all random quantities.

The complex amplitude of the field spectrum is

$$\tilde{E}(\nu) = \tilde{f}(\nu) \sum_l a_l \exp[-2\pi i c(\nu - \nu_0)\theta_l + i\phi_l]_r .$$

Since the number of terms in the sum is large (it is determined by the width of the spectrum and amounts to $\sim 10^2$ and $\sim 10^3$ for the ruby and neodymium-glass lasers, respectively), the sum has a normal distribution in the complex plane. The intensity relative to $[\tilde{f}(\nu)]^2$, i.e., the square of the modulus of the sum, has a distribution given by $(1/I_0)\exp(-I/I_0)$. The correlation frequency interval (the minimum frequency interval in which the intensity changes by an amount on the order of the mean value) is determined by the reciprocal of the time interval in which the spikes lie. When the axial period is filled with spikes more or less uniformly, the correlation interval has a value on the order of the intermode distance $\delta\nu_m = 1/L \approx 0.006$ cm^{-1}. When the spectra are registered with a spectral instrument having a resolution $\delta\nu$, the average relative deviations of the spectrum intensity from the mean value are close to $\sqrt{\delta\nu_m/\delta\nu}$, and usually amount to several times ten per cent. In our case, for the neodymium-glass laser $\sqrt{\delta\nu_m/\delta\nu} \approx 0.2$ ($\delta\nu = 0.1$ cm^{-1}) and for the ruby laser $\sqrt{\delta\nu_m/\delta\nu} \approx 0.6$ ($\delta\nu = 0.015$ cm^{-1}). Such intensity deviations should become clearly manifest in the spectrum, as is indeed observed in the experiment (Fig. 2).

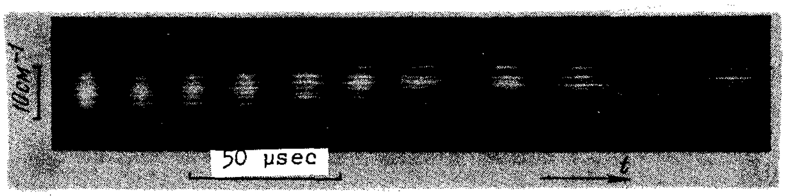

Fig. 3. Scanned spectrum of the neodymium-glass laser spikes.

As already indicated, the irregular structure is typical of all the free-generation spikes. Figure 3 shows the scanned spectrum of the free generation of the neodymium-glass laser. We see that the structure of the spectrum of each spike duplicates qualitatively the structure of the spectrum of the preceding spike. This indicates that the spike emission field cannot attenuate to the level of the spontaneous noise within the time needed for the development of the next spike.

From the point of view of the developed concepts concerning the temporal and spectral characteristic of the laser emission, the transition from a broad spectrum to a single-mode spectrum observed by us [1, 5] during the course of generation corresponds to a broadening of the fluctuation peaks of the field as they pass through the amplifying medium, owing to the finite relaxation time, with the broadening of the spikes continuing until they are completely smoothed out.

Thus, the observed structure of the free-generation spectra is an inherent property of solid-state lasers in which a large number of axial modes is excited, and confirms the fluctuating character of the emission field.

It should be noted that an irregular spectral structure was observed by us also in ruby and neodymium-glass lasers with passive shutters. This structure can also be attributed to the fluctuating character of the radiation field. However, in addition to spectra with irregular structures, these lasers exhibit under certain conditions also "smooth" spectra (accurate to within the intermode distance), which we attribute to the presence of only one pulse in the axial period, i.e., to complete mode locking.

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NEW SUPERCONDUCTING MODIFICATIONS OF BISMUTH

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Bridgman established in his time, by measuring the volume compressibility, that bismuth has five polymorphic transformation under pressure at room temperature. The values of the transformation pressures determined by him were P_{I-II} = 25.3 kbar, P_{II-III} = 27.0 kbar, P_{III-IV} = 44.8 kbar, P_{IV-V} = 65.0 kbar, and R_{V-VI} = 79.8 kbar [1].

In the transformations III-IV and IV-v, the volume change $\Delta V/V_0$ was small, approximately 0.5%. Subsequent investigations of the P-T diagram of bismuth did not confirm the presence of the last three transformations. Later on Bundy observed a large jump of resistance above the pressure of the V-VI transition [2].

Zeitlin and Brayman, using a cubic press and samples of great length, recently measured the electric resistance of bismuth under pressure at room temperature, and observed resistance jumps corresponding to five transformations, which they ascribed to the transitions I-II, II-III, III-IV, and IV-V obtained by Bridgman, and to the transition found by Bundy, which they designated V-VI [3]. The relative change of the electric resistance obtained in [3] amounts to 1 - 3% for the III-IV transition and to 1 - 2% for the IV-V transition.

The modification of Bi II and Bi III [4 - 6] and Bi VI[1] [7] are superconducting. We have investigated the properties ob bismuth in the pressure range 30 - 100 kbar, for the purpose of observing the superconductivity of the modifications Bi IV and Bi V.

The measurements were performed with a fixed-pressure setup [8]. The procedure was modernized by using a high-pressure chamber of a new type[2]. The chamber made it possible to perform the measurements on a vertically positioned sample. The pressure-transmitting media were pyrophyllite and silver chloride.

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[1] In accord with [3], we designate as Bi VI the modification designated by Bundy as Bi VIII.
[2] We are grateful to L.F. Vereshchagin, L.G. Khvostantsev, and A.P. Novikov for furnishing the chamber that they developed.