SOLID STATE LASER WITH MODE SELECTION WITHIN AN ACTIVE ELEMENT

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Many laser applications (e.g., frequency conversion, holography) require a high degree of collimation and homogeneity of the light beam. Existing methods of suppressing transverse higher-order modes in a laser beam are based on limitation of either the spatial structure of the light beam, or of its angular spectrum, with the aid of additional elements (diaphragms [1], Fabry-Perot interferometers [2], total internal reflection prisms [3]) placed inside the laser cavity. * These elements introduce as a rule considerable losses, increasing the threshold pump power and lowering the useful power of the generator. In high-power solid-state pulsed lasers, the use of selecting elements is frequently hindered by their insufficient thermal endurance and life.

We describe below a solid-state pulsed laser free to a considerable degree of these shortcomings. Its selective element is the active medium itself.

A diagram of the generator is shown in Fig. 1. The active rod is in the form of a prism of rectangular cross section with two plane-parallel polished surfaces. The two other surfaces can be made dull to distribute the illumination more evenly. Pumping is by two straight flash lamps parallel to the unpolished faces of the prism and located inside elliptic reflectors.

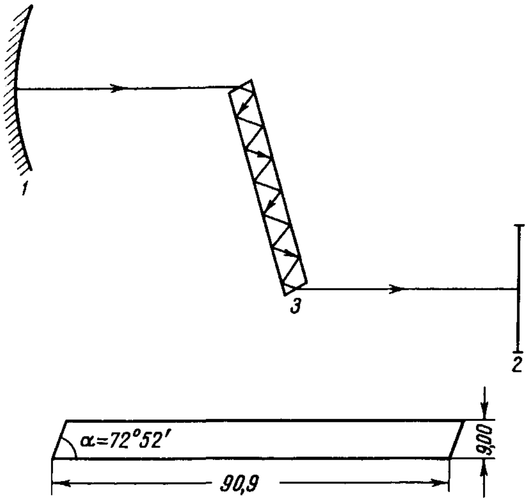

Fig. 1. Laser diagram. 1,2 - mirrors, 3 - active element.

The light beam enters the prism at the Brewster angle to the end faces and travels inside the prism, undergoing numerous reflections from the polished faces. The angle θ_3 between the beam and the normal to the faces is somewhat larger than the total internal reflection angle θ_1. As a result, the beam angle-spectrum components emitted through the faces are those making an angle larger than $\theta_3 - \theta_1$ to the axis. Passage of the beam through the cavity in one direction leads only to a unilateral cutoff of its angle spectrum, but it can be readily seen that a complete (round-trip) passage is accompanied by a symmetrical limitation of the spectrum in the selection plane. The permissible beam divergence in this plane (with allowance for higher-order modes) is $2(\theta_3 - \theta_1)$ and can be regulated by varying the angle between the longitudinal prism axis and the planes of the cavity reflectors. In the case when the beam has a single-mode structure (in the selection plane) the quantity $2(\theta_3 - \theta_1)$

is approximately equal to the divergence of the fundamental mode of the cavity.

The selecting prism of the investigated laser was made of glass activated with Nd^{+++} with a refractive index $n = 1.554$ at a generation wavelength $\lambda = 1.06\ \mu$. The prism dimensions are shown in Fig. 1. The output mirror of the cavity was plane, and the other was spherical ($R = 10$ m). The reflection coefficients were 70% and 98% for the flat and spherical mirrors. The length of the resonator along the beam is 50 cm. The light beam was reflected six times from each of the polished faces of the prism. The angle $\theta_3 - \theta_1$ was chosen experimentally in accord with the threshold pump power.

Examples of the field structures in the near and far zones of the generator, at different ratios of pump energy W to threshold W_{thr} are shown in Fig. 2. In practice, the beam divergence and the dimension of the generation region on the end face of the prism in the selection plane do not change in the entire investigated pumping range (up to $W/W_{thr} = 6$), at which the beam divergence is equal to the diffraction limit. At the prism position corresponding to the mode selection, the threshold pump exceeds by only a few per cent the value of W_{thr} at larger angles $\theta_3 - \theta_1$, when there is no selection.

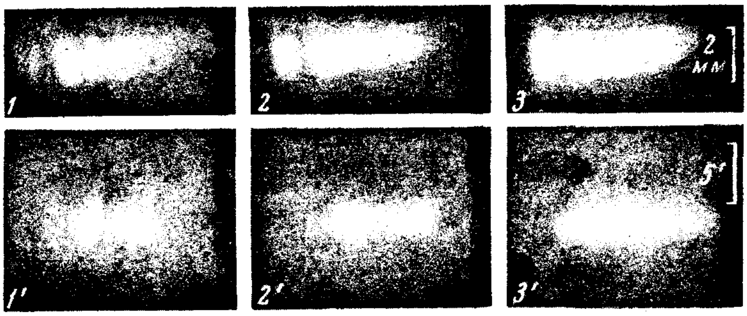

Fig.2. Picture of field on end face of prism (1 - 3) and in far zone (1'-3'); $W/W_{thr} = 1$ (1,1'), 2 (2,2'), 3 (3,3').

The frequency spectrum of the laser, obtained with the aid of a Fabry-Perot interferometer, is shown in Fig. 3. It is much narrower than in a laser without selection operating at the same pump to threshold ratio ($\Delta\lambda = 10 - 15$ Å at $W/W_{thr} = 2 - 3$), apparently as a result of the dependence of the angle θ_1 on the frequency.

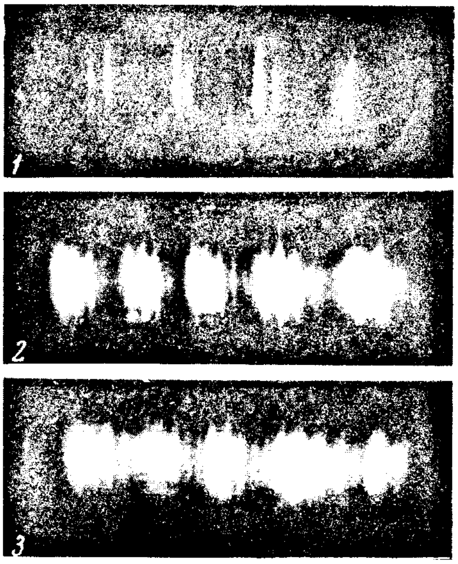

Fig.3. Interference pattern of laser frequency spectrum; distance between interferometer plates 0.3 mm. $W/W_{thr} = 1(1)$, $2(2)$ or $3(3)$.

The described laser ensures collimation of the beam in one plane. It may be useful in second-harmonic generation and parametric frequency conversion systems, in which small beam divergence is required in the synchronism plane only. Collimation in two planes can be realized by means of two active prisms placed in mutually perpendicular planes. To introduce the beam into the second prism at the Brewster angle one can either employ a half-wave plate to rotate the plane of polarization 90°, or cut the ends of the second prism in a special manner. Giant pulses can be obtained by replacing one of the mirrors by a rotating prism. The use of saturable filters for this purpose will apparently yield a pulsed generator with high degree of collimation and monochromaticity of the beam.

In conclusion we note that the operating position of the prism in the cavity depends to some degree on its temperature conditions. However, at a constant pulse repetition frequency this circumstance introduces practically no complication in the laser operation. To be sure, at the prism position corresponding to mode selection one observes an appreciable rise in threshold pump (by a factor 3 - 4) for the first lasing pulse, but after the next two or three pulses the threshold pumping drops to the statinary level.

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* The possibility of combined mode selection using simultaneous spatial and angular limitation is considered in [4].

CORRELATION OF FINAL CHARGE STATES OF PARTICLES IN DISCRETE ENERGY LOSSES IN ATOMIC COLLISIONS

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To explain the discrete energy losses in atomic collisions [1,2], models based on the concepts of single-electron [3] and collective [4,5] excitation have been proposed. Since none of these interpretations can as yet be regarded as unique, it is necessary to obtain additional experimental data on the singularites of inelastic atomic collisions.

Fano and Lichten [3] propose that for Ar$^+$ + Ar collisions the excess-inelastic-loss line R_I^* (53 eV) corresponds to removal of M-electrons, while the lines R_{II}^* (263 eV) and R_{III}^* (475 eV) are connected with formation of L-vacancies in one or both colliding particles, respectively, accompanied by Auger transitions after the scattering. If this is the scheme of the process, then an identical correlation should appear for the final charge states of the particles upon excitation of the lines R_I^* and R_{III}^*, whereas excitation of the R_{II}^* line is connected with introduction of additional inverse correlation. Of considerable interest to the interpretation of the discrete-loss mechanism is therefore an analysis of the correlation of the final charge states upon excitation of each of the discrete-loss lines.

The correlation of the final charge states was investigated for the processes Ar$^+$ + Ar $\rightarrow$ Ar^{m+} + Ar^{n+} + (m + n - 1)e (denoted 1,0,m,n for short) under condition when all three lines are simultaneously excited (energy of incoming particles T_0 = 50 keV, their laboratory scattering angle ν = 7°30'). A coincidence method was used to determine the relative probabilities of the elementary processes 1,0,m,n upon excitation of each of the lines. Inasmuch as the approach distance was fixed, all collisions corresponded to one and the same pattern of electron term crossing.

In the analysis of the experimental data, we used the standard methods of correlation theory. In particular, we considered the lines of regression of n with respect to m and of m with respect to n (see the figure), i.e., the dependence of the conditional mathematical