[6] V.L. Broude and E.F. Sheka, in: Kvantovaya elektronika (Quantum Electronics), Kiev, 1966, p. 188.

SUPERLUMINESCENCE AND GENERATION OF STIMULATED RADIATION UNDER INTERNAL-REFLECTION CONDITIONS

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It is customarily assumed that the coefficient R of reflection of light from an interface between two media is a quantity less than or equal to unity.

The purpose of the present communication is to show that in the case of internal reflection of light from an interface between a transparent medium and a medium with inverted population cases with R >> 1 are possible, so that an internal-reflection laser can be constructed.

1. The experimental setup is shown in Fig. 1. The active element was a prism (1) of K-8 glass, the base of which was in contact with a solution (2) of rhodamine-6G mixed with nitrobenzene in ethyl alcohol (4:1). The dye concentration was 10^{-3} mole/liter. The solution was sealed with the aid of a special "pocket" equipped with a heat exchanger, through which thermostatically-controlled water was pumped.

The mirrors (99 and 50%) were installed in such a way that the resonator axis coincided with the path of the ray experiencing the internal reflection from the boundary of the prism with the dye solution. The reflection angle ϕ was approximately 89°. The pump was the second harmonic of a neodymium laser, focused on the surface of the solution with the aid of a cylindrical lens. The pump energy was ~0.1 J.

2. When the refractive index n of the solution is properly chosen (a rough adjustment of n was effected by varying the ratio of the solvent components, and a more accurate one by varying the temperature) generation of radiation in the region of the luminescence of the solution was observed. The divergence of the light beam exceeded somewhat the diffraction divergence and equalled approximately $\sim 10^{-2}$ rad.

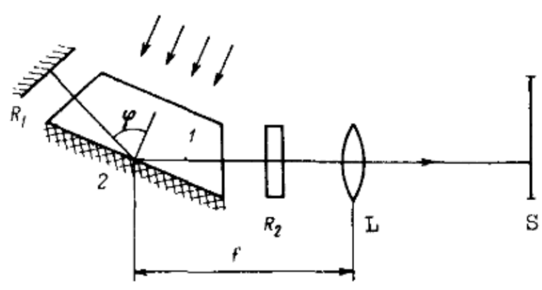

Fig. 1. Experimental setup: 1 - prism, 2 - active medium, R_1 and R_2 - mirrors, L - lens (f = 10 cm), S - spectrograph slit. The arrows show the pump direction.

The light beam was projected on the entrance slit of an STE-1 spectrograph in such a way that rays emerging from the generator at different angles struck different sections of the slit. This made it possible to register simultaneously the emission spectra at different angles of incidence of the light on the boundary between the prism and the dye solution. Figure 2 shows the spectral-angular characteristic of the radiation at different solution temperatures. The generation spectrum usually consists of a small group of narrow lines, the positions of which depend on the refractive index and consequently on the temperature of the solution. The position of the luminescence band remains in this case constant, but the character of the angular dependence of the luminescence intensity changes. The photographs show a section of the spectrum in which the direction of the luminescence radiation is bounded from above by a critical value of the angle ϕ, whose magnitude depends on the wavelength. The generation occurs at those wavelengths for which the direction of the critical angle coincides with the resonator axis. Since the critical angle depends strongly on the refractive index of the liquid, a change of several degrees in the temperature of the solution makes it possible to tune the radiation frequency over the entire luminescence band.

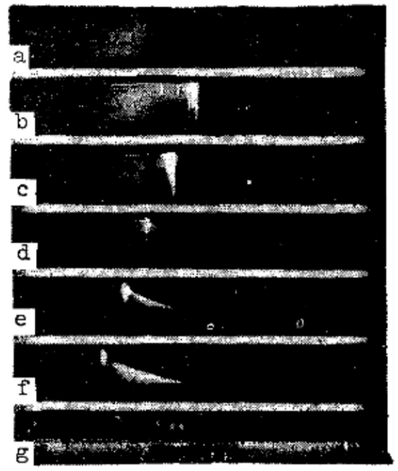

Fig. 2. Generation spectra at different temperatures: a - 13°C, b - 14°C, c - 15°C, d - 16°C, e - 17°C, f - 18°C, g - mercury-lamp spectrum.

3. In the absence of resonator mirrors we observed instead of generation a directional superluminescence with a broad spectrum. The divergence of the superluminescence radiation with respect to the angle ϕ was approximately 10^{-2} rad, indicating a strong dependence of the gain on the value of this angle. With respect to the azimuthal angle, on the other hand, the change of the intensity was small, so that the radiation was limited to the surface of a cone with a vertex angle 2ϕ. This is observed particularly clearly when the prism is replaced by a glass hemisphere and a pumping-light beam of round cross section is employed. In this case the anisotropy of the distribution of the superluminescence radiation over the azimuthal angle is determined only by the polarization of the pump radiation.

When the temperature is varied, the direction of the superluminescence radiation follows the variation of the critical angle for the internal-reflection boundary.

When the temperature was properly chosen, we were able to obtain generation in a resonator in which the mirrors are the end faces of the prism. This means that the reflection coefficient on the boundary between the glass and the solution reached in this case a value R > 25.

We consider the use of internal reflection advantageous primarily when the active medium is a thin layer, as is the case, for example, in semiconductor lasers.

PICOSECOND STRUCTURE OF THE EMISSION OF A LASER WITH A NONLINEAR ABSORBER

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It is known [1, 2] that measurement of the duration of neodymium laser pulses in the mode-locking regime by the method of two-photon luminescence yields a scatter amounting to approximately one order of magnitude. In view of the ambiguity in the interpretation of the results of correlation two-photon measurements, a detailed study of the picosecond structure of the laser emission by this method is quite difficult. Direct observations of the time structure of the radiation [3, 4] had so far a time resolution not better than $(0.5 - 2) \times 10^{-11}$ sec. In the present study we used a "picochron" electron-optical image converter with a time resolution 5×10^{-13} sec for a direct