The experimental points cluster about this line with small deviations, of which the largest is 0.38%, the rms deviation being 0.18%. The absolute values are preliminary, subject to slight changes when certain corrections are taken into account.

To prevent bubble formation in the liquids, the measurements were made at pressures 10 - 50 mm Hg higher than the saturated vapor pressure at the corresponding temperature. This gave fairly sharp diffraction patterns. Within the limits of the experimental accuracy, the measurement results were independent of the pressure in the indicated pressure range.

The measurements were made at 8.376 MHz. The results obtained at this frequency agreed, within the limits of measurement accuracy, with the results obtained at 2.695 MHz.

I am grateful to Professor Bewilogua for support during the work and for valuable discussions, and to H. Siegling for help with the measurements.

[1] P. Debye and F. W. Sears, Proc. Natl. Acad. Sci. 18, 409 and 414 (1932).

USE OF LASER TO MEASURE THE CROSS SECTION OF STIMULATED EMISSION OF MATTER

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The stimulated-emission cross section σ is one of the most important constants of active laser materials. In particular, knowledge of σ makes it possible to estimate the position of the investigated ion in the matrix. We describe below a new method of measuring σ, based on the change of intensity of the spontaneous luminescence of a medium under the influence of resonant laser radiation [1-3].

Let us examine the change of the population of the third (working) level in a four-level Q-switched laser during the lasing process. We can neglect the influence of the pump and of the spontaneous emission on the population of the metastable level during the time of the giant pulse. In this case the change of the inverted population is determined only by the field inside the cavity.

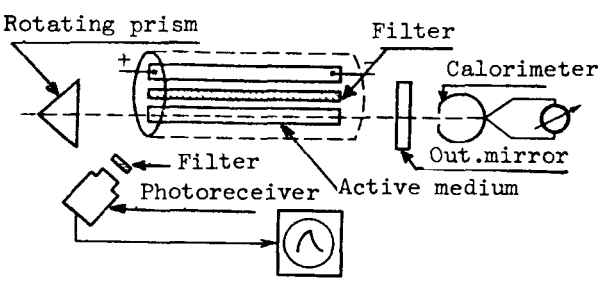

Fig. 1

Assuming that the population of the lower laser level is $N_2(t) \equiv 0$, we can write

$$\frac{dN_3}{dt} = -\sigma_{32} n(t) N_3, \tag{1}$$

where N_3 is the population of the metastable level in the four-level system, σ_{32} is the stimulated-emission cross section, and $n(t)$ is the photon flux density in the active rod during the time of lasing.

We denote by t_1 and t_2 the instants when the giant pulse begins and ends. Solving

(1) we get

$$\sigma_{32} n_o = \ln \frac{N_3(t_1)}{N_3(t_2)}, \tag{2}$$

where $n_0 = \int_{t_1}^{t_2} n(t)dt$ is the total photon flux passing in both directions through the section of the active rod during the time of lasing. Expressing n_0 in terms of the coherent-emission energy E radiated through one of the mirrors during the pulse time $\Delta t = t_1 - t_2$, as measured with a calorimeter,

$$n_o = \frac{2E}{h\nu_{32}\ S\ (1-r)}, \tag{3}$$

where S is the cross section area of the active medium and r is the reflection coefficient of the output mirror, we get as a final expression for σ_{32}:

$$\sigma_{32} = \frac{h\nu\ S\ (1-r)}{2E} \ln \frac{N_3(t_1)}{N_3(t_2)}. \tag{4}$$

When σ_{32} and S are known, this formula can also be used to determine the radiated energy.

A block diagram of an experimental setup with which to determine E and the ratio $N_3(t_1)/N_3(t_2)$ is shown in Fig. 1. A photomultiplier placed at an angle ~45° to the direction of the output beam registers in practice only the luminescence of the active medium. The harmful influence of the scattered light of the flash lamp is suppressed with the aid of filters in the illuminator and in front of the photomultiplier. The energy radiated through the output mirror is measured with a calorimeter. The laser used in the measurements had a rod of silicate glass with 2% Nd_2O_3. The Q-switching was with a prism rotating at 2×10^4 rpm. The measurements were made for two output mirrors, with r = 74% and r = 89%. The cross section for the cylindrical active rod was 0.4 cm^2. A typical photograph of the photomultiplier signal is shown in Fig. 2, on which t_1 and t_2 are practically indistinuishable.

The results of the measurements yield for KGSS-3 silicate glass a value $\sigma_{32} = 2 \times 10^{-20}$ cm^2. The measurement accuracy is determined essentially by the quality of the calorimeter ana by the homogeneity of the photon flux over the cross section of the laser rod, and amounts to 15 - 20% in our measurements. Similar measurements can be made also by observing the luminescence of an individual sample exposed to an external sounding pulse from a laser. The measurement accuracy can then be greatly increased [4].

We have used in the foregoing the tacit assumption that the photon flux is constant along the active rod. A control experiment, in which two luminescence photographs from opposite ends of the active rod were processed, gave equal results. This is evidence that the photon flux density is constant along the axis of the rod, at least when the mirror transmission coefficient is small.

The method of investigating the behavior of the metastable-level population by determining the change of the luminescence under the influence of a laser pulse makes it possible

to evaluate directly the kinetics of the relaxation processes in a laser, to study excitation-transfer processes in sensitized active material, and to determine the threshold populations and the kinetics of the losses during the lasing time.

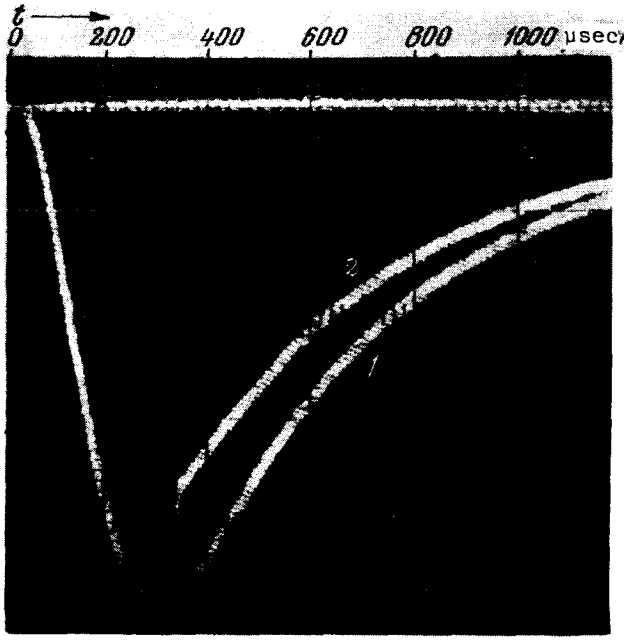

Fig. 2. Oscillogram of sample luminescence. 1 - no lasing; 2 - lasing the the giant-pulse mode. The two curves coincide before the start of lasing.

The latter is illustrated by Figs. 3a and b, which show the variation of the losses during the time of free generation of glass. When the mirrors are accurately adjusted, the

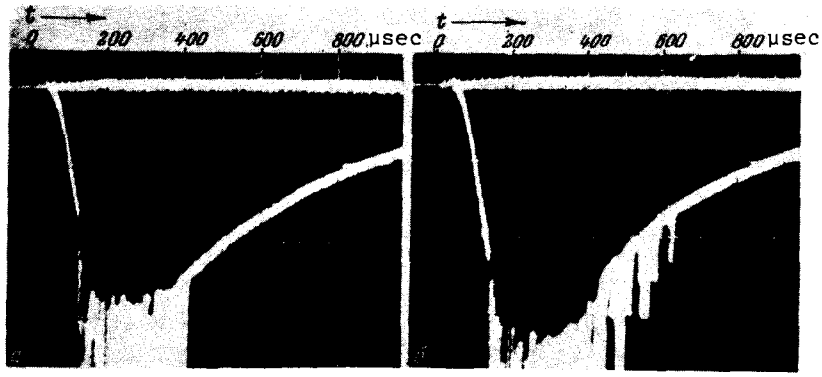

Fig. 3

threshold population increases (Fig. 3a). When the mirrors are offset by 20", the population is lower at the end of the generation than at the beginning (Fig. 3b). The connection with the adjustment shows that the effect has a geometric nature. Apparently the lens produced as a result of the heating of the rod makes the resonator worse in the former case and compensates for the poor adjustment in the latter.

The proposed procedure is applicable also to three-level systems, provided the popula-

tion of the ground state is taken into consideration.

[1] A. Srabo and F. R. Lipsett, Proc. IRE 50, 1690 (1962).
[2] M. D. Galanin and Z. A. Chizhikova, Opt. Spektrosk. 17, 402 (1964)
[3] M. Michon, IEEE J. of Quantum Electr. 2, 612 (1966).
[4] V. P. Belan, V. V. Grigor'yants, and M. E. Zhabotinskii, Paper at Conf. on Laser Application, Washington, D.C., 6-8 June 1967.

OBSERVATION OF TRANSFORMATION OF A SEMICONDUCTOR INTO A METAL IN A MAGNETIC FIELD

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1. It was shown in [1] that a transition from the metallic state to the semiconducing state (dielectric at 0°K), or conversely the transformation of a semiconductor (dielectric) into a metal, depending on the ratio of the spin and cyclotron effective carrier masses, can be observed in substances having an even number of electrons per unit cell if the magnetic field is strong enough.

These effects are easiest to observe in objects with small band overlap or with small energy gap between bands. The metals with minimum overlap are bismuth and antimony. Neither, however, goes over into the dielectric state in a magnetic field: In bismuth the band overlap increases in the field, owing to the small spin carrier mass [2], and in antimony the attainable fields (H = 450 kOe) are insufficient for a transition into the ultraquantum region [3]. From this point of view, special interest is attached to the system of Bi-Sb solid solutions in the concentration range from 0 to ~10 at.% Sb. When the antimony concentration increases, the band overlap decreases and vanishes at ~5 at.% Sb, after which an energy gap is produced in the Bi-Sb spectrum [4,5].

2. The investigation of the solid solutions at concentrations 0 - 5 at.% Sb * shows that the overlap increases in a magnetic field, i.e., the picture is similar to that in bismuth. It was therefore to be expected that if the antimony content exceeds 5 at.%, when a gap appears, the gap will decrease in strong magnetic fields and will vanish at a certain critical value H_{cr}, so that the semiconducting alloy will go over into the metallic state.

3. We present here the results of an investigation of the magnetoresistance of single-crystal samples of Bi-Sb with antimony concentrations ~5, ~9, and ~12 at.%, in magnetic fields up to 420 kOe at liquid helium temperatures, and in different crystallographic orientations. The measurement procedure is similar to that described in [2]. The samples had the form of parallelepipeds with dimensions ~2 x 0.3 x 0.3 mm.

Measurement of the temperature dependence of the electric resistance at H = 0 has revealed also a semiconductor dependence for samples of all compositions. A slight increase of the resistance with decreasing temperature of the $Bi_{95}Sb_5$ samples ($\rho_{4.2°K}/\rho_{300°K}$ = 3.5) indicates that no noticeable energy gap has yet been produced. In the $Bi_{91}Sb_9$ and $Bi_{88}Sb_{12}$ samples a strong increase of resistance, of the semiconductor type, is observed ($\rho_{4.2°K}/\rho_{300°K}$ = 107 for $Bi_{91}Sb_9$ and $\rho_{4.2°K}/\rho_{300°K}$ = 220 for $Bi_{88}Sb_{12}$). The near-exponential character of