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* The nature of the considered effect differs greatly from that described in [5], where apparently the incident beam was essentially reflected specularly from the region of matter where the refractive index was changed by the powerful laser light, and there was no change of frequency of the scattered light.

SELF-SYNCHRONIZATION OF MODES IN A GaAs SEMICONDUCTOR INJECTION LASER

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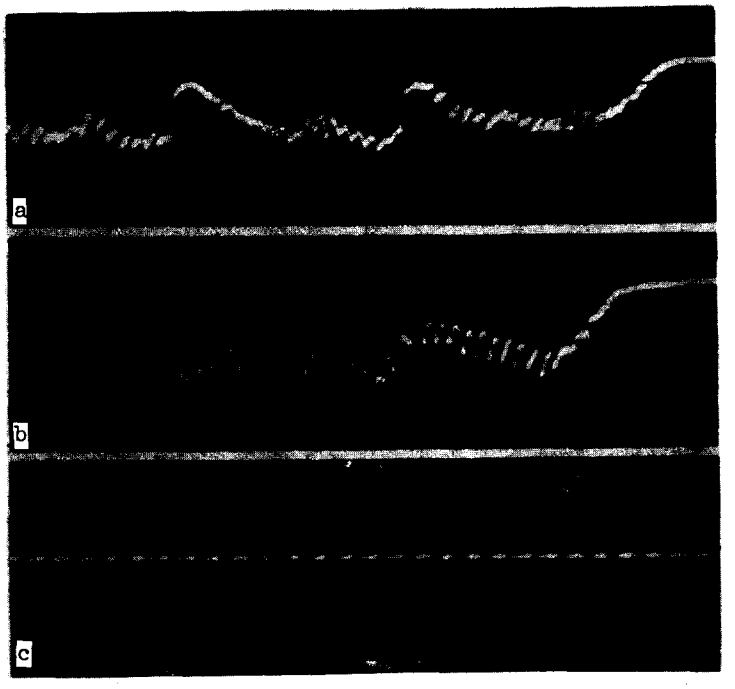
The purpose of the present note is to report observation of self-synchronization of axial modes in a laser diode with external mirror. The mode capture effect was manifest in the occurrence, as a result of the nonlinearity of the active medium*, of a series of coherent modes, equally spaced in frequency, and the summary field due to the interference between them was a sequence of pulses spaced 2L/c apart and with duration 2L/Kc, where L is the optical length of the resonator, c the speed of light, and K the number of synchronized coherent modes. This phenomenon is of interest in connection with the possibility of obtaining ultrashort periodic pulses of coherent light. The self-synchronization of the modes was investi-



Oscillograms of emission of an injection laser diode with external mirror: a - unifrom excitation, pump power 2.7 A, threshold 2.4 A; b - non-unifrom excitation, pump current 5A, threshold 4.6 A; c - 10^{-8} sec timing markers.

gated for solid-state and gas lasers [1-6]. We present below preliminary results of mode self-capture in semiconductor lasers.

The laser diode was placed in a vacuum cryostat on a copper cold finger at liquid-nitrogen temperature. The radiation emerging from one side of the diode was guided with the aid of a lens to the outer mirror (reflection coefficient ~98%). The radiation reflected from the mirror was focused with the same lens on the active region of the p-n junction. The radiation was recorded from the opposite side of the diode with the aid of a photomultiplier having a time delay $\sim 2.5 \times 10^{-9}$ sec. To reduce the effect of vibrations, the optical system was mounted on a concrete base. Depending on the distance to the mirror, the lasing threshold was decreased by 10 - 20%. To study the influence of the nonlinear absorption, we also investigated "slotted" diodes [9] with uniform and non-uniform pumping over the area of the p-n junction. Figure a shows a typical time dependence of the emission intensity for a slotted diode with uniform excitation at a distance L = 75 cm to the mirror. Oscillations of the emission intensity with a period 5×10^{-9} sec, corresponding to the distance between the neighboring axial modes of a resonator 75 cm long, were observed against the background of the relaxation oscillations with duration $\sim 70 \times 10^{-9}$ sec. The small depth of modulation may be connected both with the fact that the number of synchronized modes is small compared with their total number, and with the fact that the time delay of the photomultiplier is comparable with the pulse repetition period. The oscillogram on Fig. b shows the emission of the same diode when current flows in only one part of the diode (non-uniform excitation), and the other part operates as a nonlinear absorber. We see that the depth of the modulation increased, while the period remained constant. This can be due only to an increase in the number of synchronized modes. Similar results were obtained at a distance ~35 cm to the mirror. In both cases, the repetition period of the pulses against the background of the relaxation oscillations does not depend on the excess of the current above threshold and coincides with 2L/c with good accuracy.

We note also that whereas the spectrum of a semiconductor laser without an external mirror, operating near threshold, consists of a small number of lines corresponding to excitation of axial modes determined by the length of the diode, the spectrum in the generation regime is much broader when operating with an external mirror (half-width ~15 Å). We observed no discrete lines corresponding to the modes of the diode operating without an external mirror (spectrometer resolution ~0.5 Å). The broad spectrum shows that when working with an external mirror there are generated simultaneously a large number of modes of the composite resonator made up of the faces of the diode and the external mirror. A line width ~15 Å subtends $\sim 10^3$ such modes, corresponding to a resonator length of 75 cm. Simultaneous generation of a large number of modes is an advantage offered by a semiconductor laser with an external mirror, since self-synchronization of even a small fraction of the total number of modes should lead to the appearance of periodic radiation pulsations. In addition, by moving the external mirror it is possible to regulate the frequency of the pulses radiated by the semiconductor laser. The use of apparatus with higher time resolution will make it

possible to study the shape of the light pulses produced as a result of the mode self-capture in a semiconductor laser with an external mirror, and to determine the number of self-synchronized modes.

The realization of the self-synchronization of the majority of modes in a semiconductor laser will make it possible to obtain ultrashort pulses of coherent light of $\sim 10^{-12}$ sec duration and with a repetition frequency from 10^{11} to 10^{8} Hz.

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* Self capture of modes is realized effectively when the resonator Q is modulated by an external force at a frequency close to the difference between the frequencies of the axial modes or with the aid of an additional nonlinearity, produced for example by saturable filters [6-8].

ANOMALOUS TRANSMISSION OF X-RAYS IN TIN SINGLE CRYSTALS

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When x-rays pass through perfect or near-perfect crystals at the Bragg angle to the crystallographic planes, the absorption coefficient for the transmitted beam becomes anomalously low.

This phenomenon, first observed by Borrmann in quartz single crystals [1] and investigated subsequently also in calcite, germanium, and silicon [2-5], served as the basis for the development of a new method of studying thermal vibrations in crystals, of determining the Debye temperature, and also to observe and control various types of disturbances to the

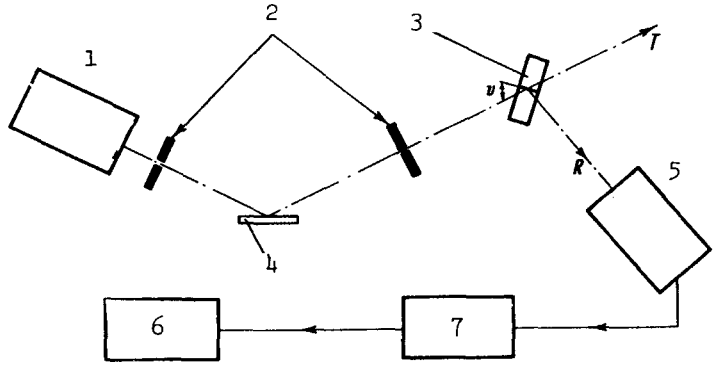

Fig. 1. Experimental setup: 1 - x-ray tube, 2 - diaphragms, 3 - investigated single crystal, 4 - monochromator - quartz [10$\bar{1}$1], 5 - scintillation counter, 6 - recording unit, 7 - pulse-height analyzer.