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HYSTERESIS AND "HARD" EXCITATION IN A GAS LASER

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We call brief attention in this paper to the observation of new effects - hysteresis phenomena and "hard" excitation in a gas laser in whose cavity is placed an absorbing medium with a saturation parameter which is smaller than the saturation parameter in the active medium [1]. The hysteresis observed in the one-mode and multimode cavity regimes cannot be attributed to competition and interaction of the modes.

The experiments were made with a He-Ne laser at $\lambda = 0.63\ \mu$ with an absorption cell. The distance between mirrors was 64 cm. The amplification tube was 25 cm long and 2.5 mm in diameter and was filled with an He-Ne mixture. A high-frequency discharge was excited in the absorption tube, which was filled with pure neon.

As follows from [1], when $T_0/G_0 > \Gamma_2/\Gamma_1 > 1$, where T_0 and G_0 are the unsaturated absorption and gain at the line center and Γ_2 and Γ_1 are the Lorentz half-widths in the absorbing and amplifying media, respectively, the resultant gain in the system, i.e., the difference G - T, increases with increasing field. Physically this means that the decrease in absorption exceeds the decrease in the gain in the amplification tube. As shown recently by Kazantsev et al. [2], the solutions for the field in the resonator can be obtained in this case by taking into account the fifth-order terms of the expansion in terms of the field. They have shown that two solutions are possible at certain ratios of the parameters of the media and of the resonator, one of which is always unstable. These results are plotted qualitatively in Fig. 1, which shows the field dependence of the gain G, the absorption T, and of their difference G - T. The points where the line parallel to the abscissa axis crosses the G - T plot yield the solution for the field for a given value of the loss R. The point lying to the left of the maximum gives the unstable solution, and the point to the right of the maximum corresponds to stable generation.

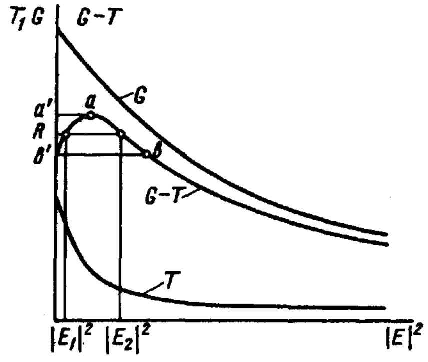

Fig. 1. Gain G, absorption T, and their difference vs. the field

Generation is impossible above the point a. In the region between the points a and b there exists a "hard" self-excitation regime. It is in this region where the hysteresis phenomena take place. By "hard" regime of laser self-excitation we mean the usual condition of oscillator excitation in radio engineering, whereby the oscillations are produced in the oscillator only when their amplitude exceeds a certain critical value. In our case, stable generation at a loss R can occur when the field in the resonator exceeds a value E_1, at which stable generation with amplitude E_2 sets in. Below the point b we have the usual "soft" self-excitation regime.

Hysteresis of three types could be observed: when the loss in the cavity changed, when the gain or absorption changed, and when the generation frequency changed. The first two types can be readily understood from Fig. 1. When the loss decreases, generation sets in at the point b and changes abruptly to the regime corresponding to the point b. When the loss changes in the opposite direction, generation ceases at the point a, where the loss is equal to the maximum G - T. Similar phenomena will be observed also when the absorption or gain changes. Hysteresis due to frequency change (Fig. 2) is connected with the change of the

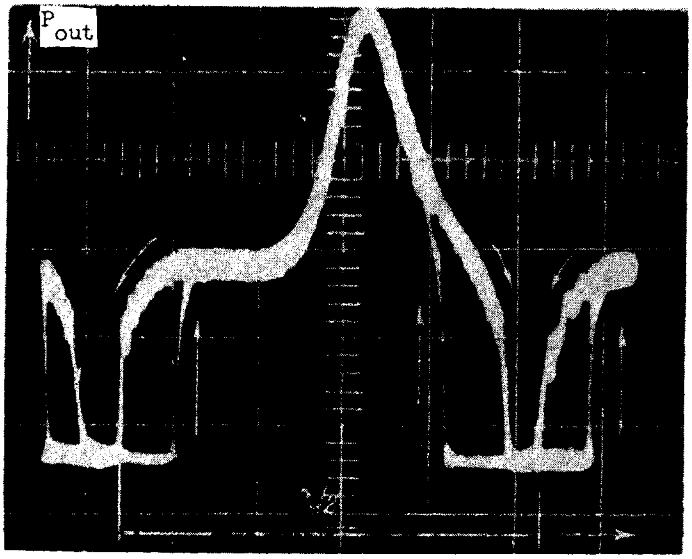

Fig. 2. Frequency dependence of generation power. Neon pressure in in the absorption tube $P_{Ne} = 0.3$ mm Hg. Helium and neon pressures in amplification tube $P_{He} = 1$ mm Hg and $P_{Ne} = 0.1$ mm Hg.

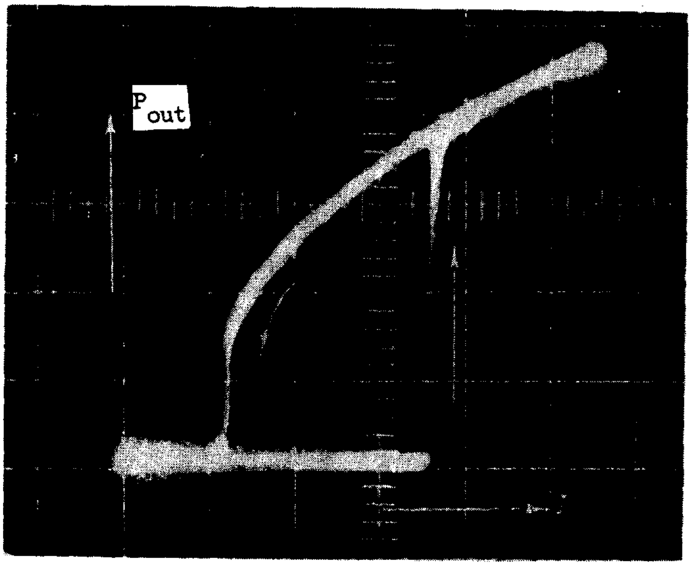

Fig. 3. Generation power vs. discharge current in amplification tube.

form of the field dependence of G - T. Hysteresis phenomena due to change in frequency were always accompanied by a peak of generation power at the center of the absorption line [1], since the conditions for the occurrence of the hysteresis were more stringent than the conditions for the appearance of the generation-power peak [1]. It has been noted that the generation growth time was always much shorter than the cessation time, in agreement with the results of Kazantsev et al.

When the discharge current in the amplification tube was varied (Fig. 3), the hysteresis region depended on the generation frequency, approximately doubling when tuned to the center of the absorption line.

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[1] V. N. Lisitsyn and V. P. Chebotaev, Zh. Eksp. Teor. Fiz. 54, No. 2 (1968) [Sov. Phys.-JETP 27, No. 2 (1968)].
[2] A. P. Kazantsev, S. G. Rautian, and G. I. Surdutovich, Paper at Scientific-technical Conference on Quantum Electronics, Erevan, October 1967.

INFLUENCE OF EXTERNAL ELECTRIC FIELD ON THE SPEED OF SOUND IN CdS

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Increasing attention is being paid at present to the nonlinearity of the electron-phonon interaction processes, since they limit the amplification of sound and cause formation of stationary waves in piezoelectric semiconductors.

It turns out that in a number of cases an important role is played in these processes by the dependence of the speed of sound w on the external electric field [1]. The linear theory of this dependence, developed by White [2], leads to the following result:

$$w = w_0 \left(1 + \frac{K^2}{2} \phi\right),$$

where (1)

$$w_0 = \sqrt{\frac{c}{\rho}}, \quad \phi = \frac{(q/\kappa)^2 (1 + q^2/\kappa^2) + (\omega - qv)^2 \tau_\sigma^2}{(1 + q^2/\kappa^2)^2 + (\omega - qv)^2 \tau_\sigma^2},$$

c - elastic modulus, ρ - density, K - electromechanical coupling coefficient, q - wave vector of the sound wave, κ - reciprocal Debye radius, ω - sound frequency, v - electron drift velocity, and τ_σ - conductivity relaxation time.

The value of φ depends not only on the carrier density in the sample, but also on their drift velocity in the external electric field. The smaller the difference between the electron velocity and the sound wave, the more effective the screening of the piezoelectric interaction. Therefore, a maximum in the change of velocity at a given conductivity should