to the plasma at frequency ω was observed (Fig. 3), in agreement with the theory of [5].

3. The scattered-radiation pulse coincides in duration and in time of occurrence of the pulse of noise from the plasma in the region of the second harmonic of the plasma frequency.

The author is grateful to R. A. Demirkhanov, N. I. Malykh, L. A. Utkin, and E. S. Yampol'skii for continuous interest and help with the work, and also to S. D. Fanchenko, D. D. Ryutov, and B. A. Demidov for a valuable discussion of the results.

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LASER WITH NONRESONANT FEEDBACK

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Submitted 9 February 1966
ZhETF Pis'ma 3, No. 6, 261-264, 15 March 1966

1. In quantum generators operating in the radio and optical bands, the feedback is resonant [1,2]. This is a consequence of the use of resonators (cavity in the radio band and Fabry-Perot in the optical band), which have a minimum electromagnetic-energy loss in the region of relatively narrow frequency intervals. Generators with resonant feedback therefore emit one or several modes, which usually interact weakly with one another and can be regarded as isolated.

In this letter we report achievement of laser action with nonresonant feedback using high-gain ruby crystals. The nonresonant feedback was by backward scattering from a volume or a surface. When a light wave is incident on the scatterer, one part of the energy is dissipated in other modes of the "resonator" and another part leaves the scatterer. As a result, the resonator modes interact strongly and, strictly speaking, are not isolated. The natural-frequency spectrum of such a "stochastic" resonator is continuous. The lack of resonant properties in a stochastic resonator signifies that the generation frequency should not depend on the length of the resonator, but should be determined by the resonant frequency of the active medium.

2. The diagram of the laser is shown in Fig. 1. The active medium comprises two ruby crystals 2 and 3 in series, each 24 cm long and 1.8 cm in diameter, whose ends are cut at the Brewster angle to prevent self excitation. The feedback was produced with the aid of mirror 4, which reflected 99% of the light, and a volume or surface scatterer 1. The volume scat-

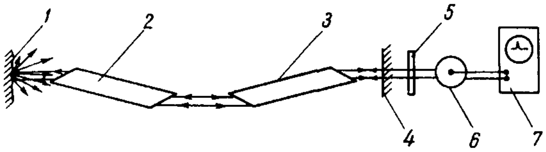

Fig. 1. Diagram of experiment

terer was a suspension of chalk particles with diameter not more than 2 x 10^{-3} cm in water, and the surface scatterer was a plate with a layer of sputtered MgO. The light flux transmitted by mirror 4 and attenuated by filter 5 was recorded by photocell 6 and oscilloscope 7, and its spectrum was measured with a Fabry-Perot interferometer. The gain of the weak signal in one passage through the two crystals reached 900.

3. The condition of self excitation of the laser was in our case ($\Omega_{sc} \gg \Omega_{gen}$):

$$k^2 r \frac{\Omega_{gen}}{\Omega_{sc}} \frac{\alpha}{2} = 1, \qquad (1)$$

where k is the gain in one passage, r the reflection coefficient of the mirror, Ω_{gen} the effective solid angle in which the generated radiation propagates, Ω_{sc} the effective solid angle of backward scattering, and α the back scattering coefficient in an ange 2π (sr); the factor 1/2 is due to the complete depolarization of the radiation upon scattering. Approximately we can set $\Omega_{gen} = (P/L)^2$, where P is the crystal diameter and L the average distance between the mirror and the scatterer. For an ideal scatterer $\Omega_{sc} = 2\pi$. In the experiment L = 100 cm, P = 1.8 cm, and $r \simeq 1.0$. For scattering from a surface $\alpha \simeq 0.9$ and $\Omega_{sc} = 2\pi$, and for volume scattering $\alpha \simeq 0.5$ but $\Omega_{sc} < 2\pi$. Therefore the threshold gain in one passage is of the same order in both cases, $k \simeq 200$. The use of mirror 4 in the laser mode does not lead to the appearance of resonant properties, but greatly reduces the generation threshold. If two scatterers were used, the attained generation threshold gain would be $k \simeq 4 \times 10^4$.

4. Figure 2a shows the oscillogram of the laser emission with pump energy below threshold, and Fig. 2b - with above-threshold pump energy and feedback produced by volume scattering. Figure 2b shows clearly the damped pulsations characteristic of the lasing mode. The threshold is practically independent of the angle of inclination of the scatterer, over a wide range, but increases with increasing distance between the scatterer and the crystal, in agreement with condition (1). The spectrum was investigated with the aid of a Fabry-Perot interferometer with air gap 3 cm. The radiation line width was smaller than 0.015 cm^{-1} and was determined by the resolution of the interferometer (the spontaneous emission line width of ruby is 15 cm^{-1}). An investigation of the beat radiation spectrum has shown that there are no frequencies of the c/2L type, characteristic of lasers with resonant feedback. The angular divergence of the radiation was $\sim(P/L)$, and the distribution of the radiation field in the far zone was quite homogeneous. A pulse with duration 200 nsec was obtained in the case of Q-switching of the stochastic resonator.

5. The average frequency of the generated radiation in the laser with nonresonant feedback was determined by the position of the center of the atomic transition, and not by the resonance of the feedback. It is consequently possible to produce an optical frequency standard on the basis of a laser with nonresonant feedback. It is necessary to use for this

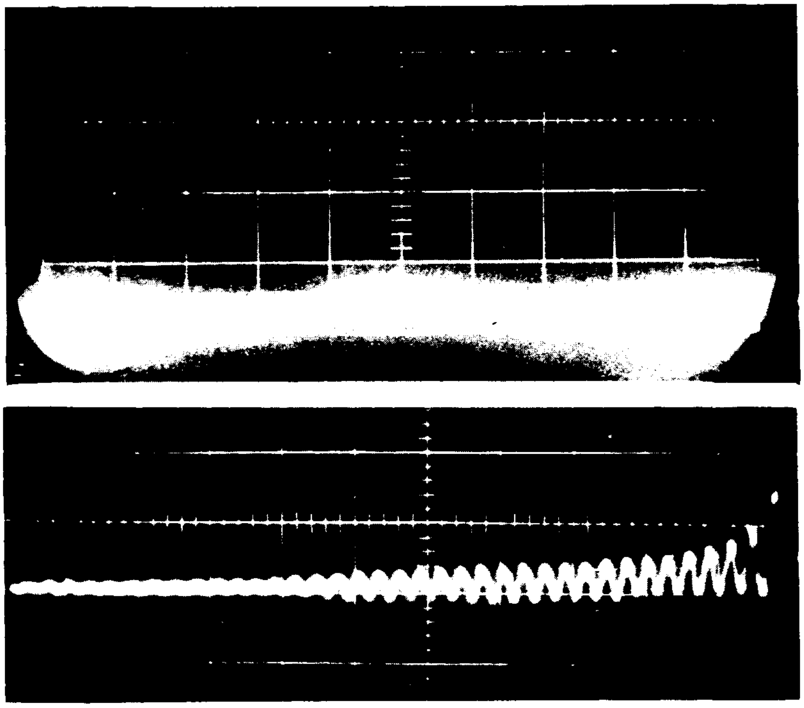

Fig. 2. Laser emission below threshold (a) and above threshold (b).

purpose high-gain atomic transitions in a gas discharge (Ne, Xe, etc.) operating in the continuous mode, and also scatterers with narrow back scattering directivity pattern.

6. It must be noted that generation with feedback due to scattering by inhomogeneities of the crystal and by the matte side surface of the crystal can limit the maximum gain. The case of generation by "random modes" by a matte side surface of a crystal was considered theoretically by Fleck [3]. In our experiment such a generation was produced at maximum pump energy, when the generation occurs in a definite cone of angles.

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CORRECTION

In the title of the article by S. M. Bilen'kii "On a Possible Method of Verifying CPT Invariance in pp Scattering," volume 3, no. 3, p. 74 (Russian p. 118), read "$\bar{p}p$ Scattering" in place of "pp Scattering."