INTENSE POWER RESONANCES OF A RING LASER WITH AN ABSORBING CELL

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1. We report here the observation of narrow intense power resonances in a ring laser with a nonlinear-absorbing cell inside the resonator. Whereas in a laser with a Fabry-Perot resonator the power resonances are due to spectral burning of the Doppler absorption line [1 - 5], the power resonances of the ring laser is connected with spatial burning of the working medium. The narrow power resonances of the ring laser, which appear at the central frequency of the absorption line, have a high contrast. The physical cause of the effect is as follows. At ring-laser generation frequencies ω far removed from the centers of the gain lines Ω_+ and absorption lines Ω_-, the waves traveling in opposite directions $\mathcal{E}_1(t) = E_1\cos(\omega t - kx + \phi_1)$ and $\mathcal{E}_2(t) = E_2\cos(\omega t + kx + \phi_2)$ interact (by virtue of the Doppler shift) with different molecules. Therefore the generation at waves $\mathcal{E}_1$ and $\mathcal{E}_2$ is independent; as a result, a two-wave radiation regime sets in when the threshold is exceeded. However, at a laser frequency coinciding with the central frequency of the gain line, the two-wave generation regime becomes energetically ineffective. Indeed, in this case the stimulated emission comes from molecules with low velocities, and modulation of the medium by the field $\mathcal{E} = \mathcal{E}_1 + \mathcal{E}_2$ which is close to a standing wave at $\mathcal{E}_1 \simeq \mathcal{E}_2$ becomes noticeable. The active medium emits in the antinodes of the field, remaining uneffected in its nodes. At the same time, in the case of the single-wave regime (e.g., when $\mathcal{E}_1 \neq 0$ and $\mathcal{E}_2 = 0$), the substance is not spatially modulated, and all the molecules radiate in the wave $\mathcal{E}_1$.

In the case when the laser frequency coincides with the central frequency Ω_- of the absorbing gas, to the contrary, the two-wave generation regime is favored, since the losses in the absorbing component decrease for the spatially modulated field.

As shown in [5 - 6], two-wave generation at $\omega \simeq \Omega_-$ should be observed in a narrow frequency interval not exceeding the homogeneous line width of the absorbing gas. Namely, at frequencies ω when the function $F(\omega) = F_+(\omega) - \mu F_-(\omega)$ is negative, the regime of one traveling wave is stable, and in the opposite case the generation is of the two-wave type. Here

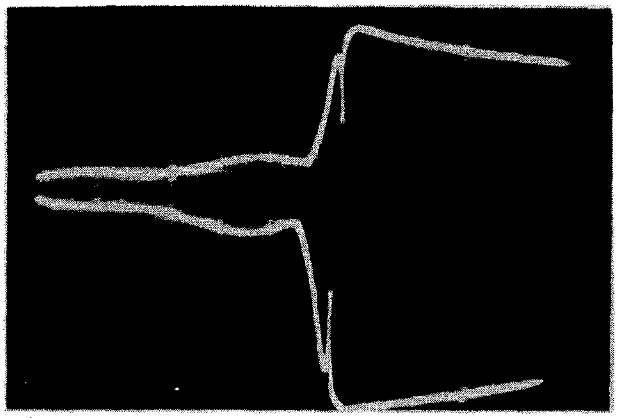
$$F_+(\omega) = 1 - L\left(\frac{\omega - \Omega_+}{\gamma_+}\right) - \left(\frac{\gamma_+}{ku_+}\right)^2, \quad F_-(\omega) = 1 - L\left(\frac{\omega - \Omega_-}{\gamma_-}\right) - \left(\frac{\gamma_-}{ku_-}\right)^2, \tag{1}$$

$$L(\xi) = (1 + \xi^2)^{-1}, \qquad \mu = |P_-^N / P_+^N| .$$

γ and ku are the homogeneous and Doppler widths of the lines, P^N is the nonlinear component of the polarization, and the plus and minus signs pertain to the amplifying and absorbing components, respectively.

Thus, the power peaks or dips appearing at $\omega \simeq \Omega_-$ in the traveling waves of the ring laser do not exceed in width the emission peaks of a laser with a Fabry-Perot interferometer (theory shows that they can be much narrower under certain conditions). The intensity of the ring-laser peaks can exceed the intensity of the Fabry-Perot resonator laser peaks by more than two orders of magnitude.

2. The experiments were performed with an He-Ne ring laser at $\lambda = 3.39$ μ, using an absorbing cell filled with low-pressure methane. Three flat dielectric mirrors with reflection coefficients $R_1 = R_2 = 96\%$ and $R_3 = 80\%$ produced the



Power oscillogram of traveling waves of a ring laser as a function of the resonator frequency. The power-peak half-width is 300 kHz.

resonator loop in the form of a triangle with perimeter $\sim 10^2$ cm. The absorbing cell was placed in one of the arms of the resonator, and gain tubes were placed in the other two: one with the isotope Ne^{20} and the other with the isotope Ne^{22}. In view of the fact that the natural frequencies of Ne^{20} and Ne^{22} are different (the frequency difference is ~ 63 MHz [7]), the function $F_{+}(\omega)$ in (1) is flatter and the peak in the emission of the ring laser, as follows from the condition $F(\omega) = 0$ and as shown by experiment, exists in a wider interval of He-Ne mixture pressures.

For a laser with one gain tube with Ne^{20}, the power peak was observed in the He-Ne^{20} mixture pressure interval from 3.5 to 5.2 Torr; in the presence of two gain tubes the range was from 1 to 14 Torr. The pressure of the helium-neon mixture in the tube with the Ne^{22} isotope was maintained in this case at the level of 1.5 Torr.

Scanning of the laser frequency on the screen of a two-beam oscilloscope revealed a power peak in the emission of one wave, and a corresponding dip in the emission of the other at the central frequency of CH_4 (see the figure). The power of the peak (dip) was 50% of the power of the wave. We note that in the ideal case (i.e., when back reflections of light from the resonator elements are eliminated), the radiation peak power should reach 100%. For comparison we investigated the power peak "due" to the Lamb emission of the methane in a laser with a Fabry-Perot resonator. The experiment was carried out under conditions close to those in the ring laser: the same resonator length, the same length of the absorbing cell, and the same pressure of the He-Ne mixture. The power peak was observed in the methane pressure range from 10^{-2} to 10^{-3} Torr and amounted to 3% of the output power.

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SUPERCONDUCTIVITY OF TITANIUM CARBIDE

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According to preceding investigations [1], titanium monocarbide, as well as other monocarbides of metals of group IV, reveals no superconductivity down