Thus, the heating and containment of the plasma by a pulsed electron beam increase on going from a mirror trap with local mirrors to a mirror trap with extended mirrors. This may be due not only to the more effective transfer of energy from the beam to the plasma, but also to improvement in the containment of the hot electrons in the field with extended mirrors.

In conclusion the authors are sincerely grateful to A. V. Gordeev and G. V. Sholin for useful discussion, and also to G. A. Kudintseva and G. M. Kuznetsova for graciously furnishing the cathodes.

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RAMAN SCATTERING OF MICROWAVES BY PLASMA OSCILLATIONS

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Much interest has been evoked recently by the use of combination (Raman) scattering of electromagnetic waves by a plasma to investigate phenomena connected with collective processes in a plasma [1].

We present in this communication the results of investigations on the nonlinear interaction of microwaves with a plasma, in which we observed Raman scattering of a 4-mm wave incident from the outside by the natural oscillations of a plasma (electron density ~ 6×10^{13} cm^{-3}) with emission of a Raman spectrum (of frequencies $\omega + \omega_{pe}$) in the 2-mm band. The scattering of the incident wave was observed from a local region in the plasma, since the wavelength and the final dimensions of the converging beam of incident electromagnetic radiation were smaller than the plasma diameter.

The experimental setup is illustrated in Fig. 1. A hydrogen plasma (with $\omega > \omega_{pe} \gg \Omega_{He}$ and $E_\omega \ll E_p$) was produced by a direct discharge (of the Penning type) from cold cathodes in a magnetic field of mirror configuration. The oscillations were excited in the plasma by a θ-pinch loop [2]. The intensity of the plasma oscillations was monitored against the level of the intrinsic microwave radiation, the spectrum of which was investigated by the method of cut-off waveguides at wavelengths 2, 4, and 8 mm. Bursts of microwave radiation occurred during the second half-cycle of the θ-pinch current. It was observed by heterodyning that the microwave radiation spectrum contained rather intense lines of plasma frequency and of the second harmonic of the plasma frequency (the electron density was monitored by means of a 4.28 mm signal passing through the plasma and reflected from it).

The external electromagnetic radiation from an antenna in the form of an ellipsoid of revolution was focused on a spot of 6 mm diameter in the center of the discharge chamber (between the loops). By using a glass section of half-wave thickness, it was possible to attenuate the level of the scattered fields at the frequencies ω and 2ω by 50 dB. In addition, a waveguide filter using a 4-mm twin-tree (frequency shift in microwave pulse ~5 Mc) made it

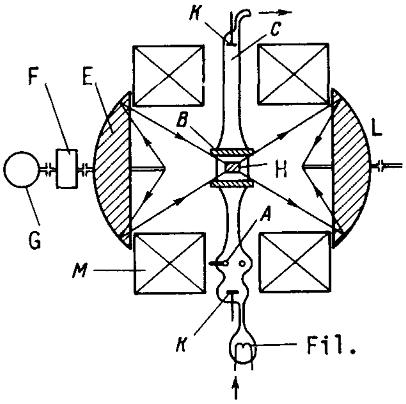

Fig. 1. Diagram of installation: G - microwave generator, F - filter, E - focusing system, M - electromagnet, C - chamber (80 mm diameter), T - pinch loop (100 mm diameter), A - anode, K - cathodes, L - microwave load, H - receiving horn.

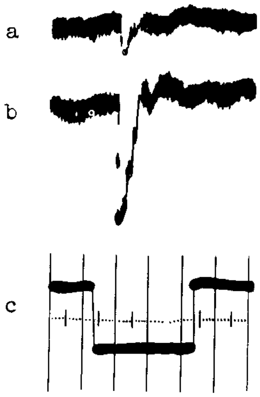

Fig. 2. Characteristic oscillograms; a - noise of frequency $2\omega_{pe}$; b - scattered radiation of frequency $\omega + \omega_{pe}$; c - microwave signal pulse of frequency ω. Time scale 0.3 μsec/div.

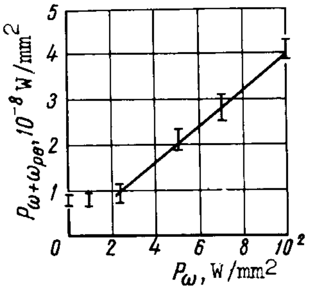

Fig. 3. Scattered radiation power vs. microwave signal power fed to the plasma.

possible to attenuate the microwave-generator harmonic further, so that the spectrum of the radiation incident on the plasma did not contain a signal of frequency 2ω.

The incident and scattered wave vectors and the magnetic vector were mutually perpendicular. The electric vector of the microwave was parallel to the constant and alternating magnetic vectors. The scattered radiation was received at a wavelength $\lambda = 2$ mm by a dc amplifier with 150 Mc video bandwidth.

A Raman scattering pulse with amplitude four times the intrinsic noise level was observed against the background of the intrinsic radiation from the plasma when the instant of development of sufficiently intense oscillations in the plasma fell in the time interval in which the microwave generator was in operation (see Fig. 2). The apparatus data are as follows: field of mirrors 3 kOe, mirror ratio 3.3; Penning discharge with C = 55 μF, U = 4kV, I = 10 kA, current rise time 10 μsec; θ pinch with C = 6 μF, U = 12 kV, I = 70 kA, period 6.3 μsec, and $p = 9 \times 10^{-4}$ mm Hg.

Identification of the observed phenomenon with Raman scattering with emission of a frequency spectrum $\omega + \omega_{pe}$ is confirmed by the following:

1. The condition $E_\omega \ll E_p \simeq 4.2 \times 10^{-10}\, \omega\sqrt{8T_e}$ [3] was satisfied in the plasma, for the critical field in the plasma under the given operating conditions was $\sim 10^2$ V/cm, and the microwave field intensity at the focus in the plasma (for a ratio $(\omega_{pe}/\omega)^2 \lesssim 1$) was of the order of 5×10^{-2} V/cm. Therefore the perturbation of the plasma by the incident microwave wave (which could manifest itself in the form of radiation at frequency 2ω scattered by the plasma oscillations induced by the microwave wave) was not observed [4] whenever the instant of microwave irradiation did not coincide with the time of development of intense natural oscillations in the plasma.

2. A linear dependence of the scattered-radiation power on the power of the signal fed

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.

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LASER WITH NONRESONANT FEEDBACK

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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-