

We can therefore expect processes occurring in the substance at high energy densities but requiring a sufficient development time (for example, breakdown of a liquid), to occur first at the turning points of the high energy density regions. It is also clear that the presence of additional phenomena in the bright spots (SRS, SMBS, breakdown, two-photon absorption, etc.) can influence a number of quantitative characteristics (the really attainable energy density of these points, their dimensions, and their relative arrangement), but introduces no qualitative changes in the obtained picture. For shorter laser pulses it may turn out that the quasistationary picture has time to become established only in the off-axis part of the beam. In this case, the final time of establishment of the Kerr effect can also influence the attainable energy density of the bright spots. For ultrashort laser pulses, all the transient processes will be significant.

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EXPERIMENTAL INVESTIGATIONS OF THE POSSIBILITY OF CONTROLLING TWO-STREAM INSTABILITY WITH THE AID OF MODULATION

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 Submitted 15 December 1967
ZhETF Pis'ma 7, No. 5, 156-160 (5 March 1968)

One of the most important problems connected with an experimental investigation of the microinstabilities in a plasma is the study of the possibility of controlling these instabilities.

In this paper we investigate the question of the control of two-stream instabilities by initially modulating the beam and by introducing an initial nonfluctuating disturbance from an external source [1,2]. We show that the intense high-frequency oscillations excited as a result of the development of a two-stream instability with a power on the order of 100 kW can be controlled by applying to the input of the beam-plasma system a very weak regular signal which is smaller by a factor $10^5 - 10^6$ than the power of the excited oscillations.

The application of an initial regular disturbance makes it possible to control the character of the excited oscillations and to transform the stochastic (irregular) oscillations into regular ones. Depending on the power of the external signal, the correlation time of the excited intense oscillations during the development of the two-stream instabilities can vary in a wide range (from 2 to 500 nsec and more).

To study the character of the excited oscillations, we investigated a method for directly observing the waveform of the excited oscillations with the aid of a high speed oscilloscope, followed by a Fourier analysis.

Since the intensity of the excited oscillations is quite high in our experiments, it was natural to expect the occurrence of nonlinear effects, particularly the appearance of harmonics of the frequency of the excited oscillations. In view of the fact that the appearance of nonlinear effects is facilitated by a decrease of the frequency (the nonlinearity parameter is

$$\mu = eE\lambda/mc^2\beta(1 - \frac{v_{ph}}{v})^2; \beta = v_{ph}/c,$$

where e and m are the charge and mass of the electron, c the velocity of light in vacuum, E the intensity of the high-frequency electric field, λ the wavelength, v_{ph} the phase velocity of the wave, and v the beam velocity), we used for the observation relatively low frequencies, much lower than the frequencies corresponding to the maximum intensity of the frequencies corresponding to the maximum intensity.

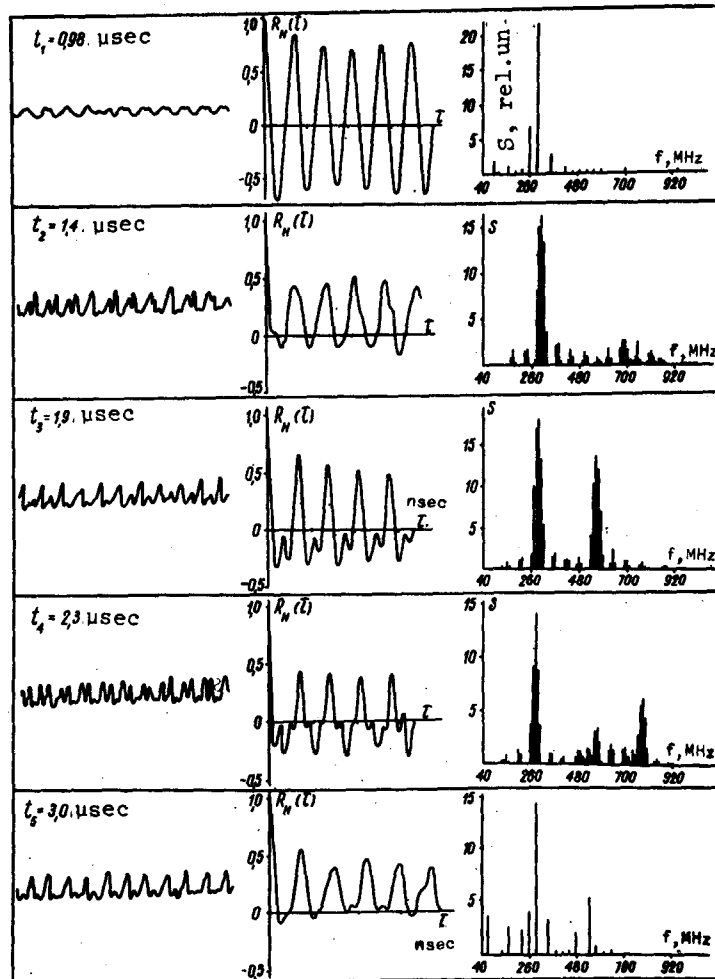


Fig. 1a

Figures 1a and 1b show the form of the excited fields, the temporal autocorrelation function, and the frequency spectrum of the excited oscillations in the presence and absence of modulation (for intense electron beams of power ~ 600 kW, 25 A, 25 keV, and pulse duration $4.5 \mu\text{sec}$, plasma electron density $n \sim (6 - 8) \times 10^{11} \text{ cm}^{-3}$, working gas nitrogen, air at pressure 6×10^{-4} Torr). The modulation frequency was 291 MHz and the modulation power ~ 6.5 kW. The magnetic field intensity reached 2000 G. The power of the excited oscillations was ~ 100 kW. Comparison of these figures shows that the modulation leads to a strong narrowing of the frequency spectrum. The correlation time also increases sharply, from $4 - 2$ nsec in the absence of modulation to $0.5 \mu\text{sec}$ in the presence of modulation,* i.e., the excited oscillations become much more regular.

A very important circumstance is that the intense oscillations can be controlled by applying to the input of the plasma-beam system a very weak regular signal, ~ 0.1 W, smaller by a factor $10^5 - 10^6$ than the power of the excited oscillations (Fig. 2).

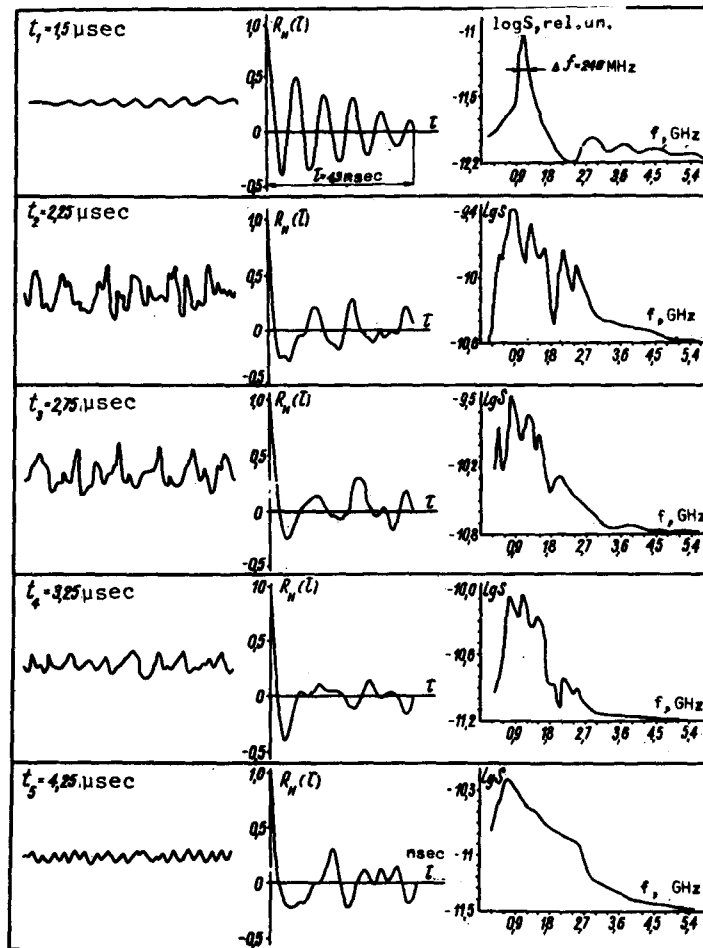


Fig. 1b

A significant difference between this case and those shown in Fig. 1a is that in the former case the modulation was at a frequency 291 MHz, which is much lower than the frequency $f \sim 880$ MHz of the excited oscillations. With this, the appreciable narrowing of the spectrum was attained at large modulation powers, ~ 6.5 kW. In the case shown in Fig. 2, the modulation was at frequencies close to those excited at maximum intensity ($f \sim 880$ MHz). In this case the powers required to control the spectrum amount to several tenths of a watt. We note that relatively large powers and low frequencies were used in earlier cases to excite nonlinear waves as a result of beam-plasma interaction. As seen from Fig. 1a, an increase of the modulation power leads to a strong nonlinearity of the excited oscillations

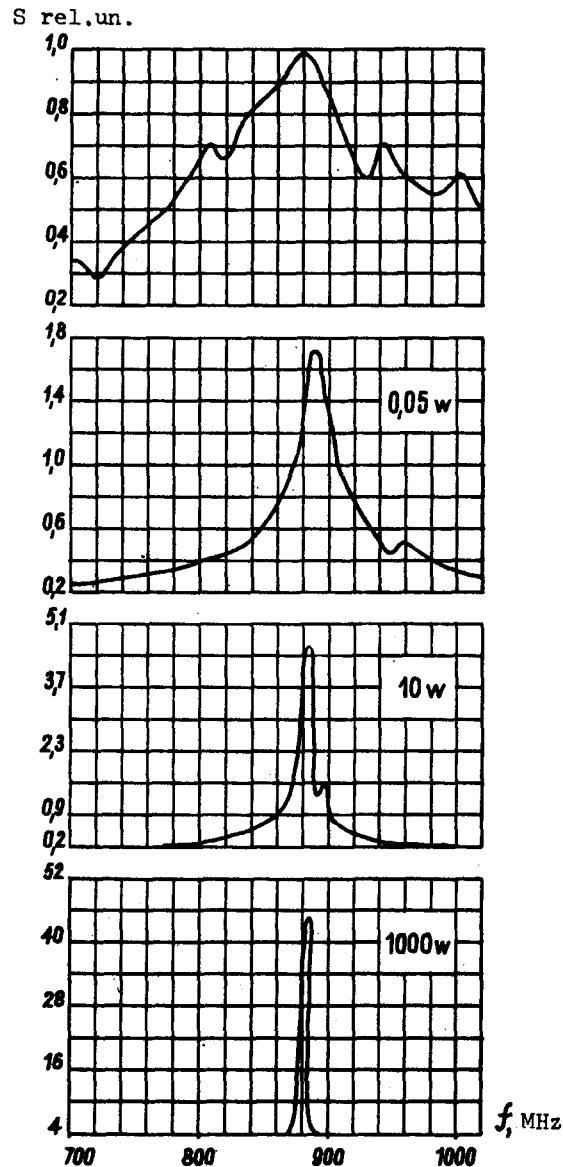


Fig. 2

(the oscillation intensity drops off at the end of the current pulse).

A detailed description of the experimental setup is contained in [3]. The high-frequency oscillations were investigated in the 100 - 7000 MHz range. The electron beam modulation and the pick-off of the high-frequency oscillation power were effected with the aid of helical junctions [3] at frequencies 291 and 880 MHz.

Thus, the experiments demonstrated the possibility of controlling two-stream instability, namely controlling the degree of regularity of the excited oscillations, the width of the spectrum, and the waveform of the excited oscillations (the degree of nonlinearity).

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* Special measurements similar to those described in [3] have shown that the correlation time increases with increasing modulation-power level as follows: 250 nsec at 6.5 kW and 500 nsec at 10 kW.

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Delete "of the frequencies corresponding to the maximum intensity" at the end of the last sentence in the page.