perature is lowered. The electrodynamic forces exciting the sound oscillations are determined by the current density and do not depend on the gas temperature. Therefore the density-oscillation amplitude A is inversely proportional to the square of the sound frequency, i.e., $A \sim T^{-1}$. Consequently, the amplitudes of the oscillations at room and helium temperatures differ by a factor of several times ten.

[1] L. D. Landau and E. M. Lifshitz, Mekhanika sploshnykh sred, Gostekhizdat, 1953 [Fluid Mechanics, Addison-Wesley, 1959].

SUPPRESSION OF CYCLOTRON INSTABILITY OF A RAREFIED PLASMA WITH THE AID OF A FEEDBACK SYSTEM

V. V. Arsenin, V. A. Zhil'tsov, V. Kh. Likhtenshtein, and V. A. Chulnov
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It is known (see, e.g., the survey [1]), that a magnetized plasma with an anisotropic ion velocity distribution ($\tau = T_\perp/T_\parallel > 1$, $T_\perp$ and $T_\parallel$ are the transverse and longitudinal temperatures) should be unstable at the ion cyclotron frequency and its harmonics $\omega \approx n\omega_{Hi}$, $n = 1, 2, \ldots$ If τ is not too large, the buildup takes place at the intersection ("resonance") of the Langmuir and cyclotron branches of the oscillations: $\omega_{0e} \approx n\omega_{Hi}$, where ω_{0e} is the electron Langmuir frequency. It is obvious that the resonance, and with it the instability, can be disrupted by turning on some mechanism of sufficiently strong damping of the Langmuir oscillations. In our investigation we introduced the damping by means of a special electronic system with feedback to controll the perturbed fields outside the plasma.

The requirements that must be satisfied by this system can be obtained by considering a simple model, viz., a cylinder ($r < a$, $|z| < b$) of a rarefied plasma ($\mu^{1/2}\omega_{0e} << \omega_{Hi}$, where μ is the ratio of the electron and ion masses), with z axis directed along an external homogenerous field $\vec{H}$. We assume for simplicity that the plasma is of uniform density and touches the metallic wall of the chamber at $r = a$. Then the perturbations of the electric potential in the natural oscillations take the form $(\phi(z)J_m(k_\perp r)\exp(im\vartheta - i\omega t)$, where ϑ is the azimuthal angle and $J_m(k_\perp a) = 0$. Assume that beyond the ends of the cylinder, on the surfaces $z = \pm d$, a certain electronic circuit maintains the conditions

$$\phi_{z=\pm d} = \delta\phi_{z=\pm b}, \tag{1}$$

where the coefficient δ, generally speaking, is complex and depends on ω. We assume also that the inequalities

$$\tau \gtrsim (\mu\zeta_n)^{-1/3}, \quad |k_\perp|^2\rho^2 >> (\mu\zeta_n)^{1/3}.$$

are satisfied, where ρ is the average Larmor radius of the ions, $\zeta_n = I_n(k_\perp^2\rho^2)\exp(-k_\perp^2\rho^2)$, and k_z is the wave number of the perturbation in the direction of $\vec{H}$. Then the dispersion equation takes the form

$$\frac{\omega_{0e}^2}{\omega^2} - 1 + \frac{\mu\omega_{0e}^2\zeta_n}{(\omega - n\omega_{Hi})^2} = \frac{k_\perp^2}{k_z^2}, \tag{2}$$

where k_z are the roots of the equation

$$\left.\begin{array}{r}\dfrac{\operatorname{tg} k_z b}{k_z}\\[2ex] -\dfrac{\operatorname{ctg} k_z b}{k_z}\end{array}\right\} = \frac{\delta(\omega) - \operatorname{ch} k_\perp (d-b)}{k_\perp \operatorname{sh} k_\perp (d-b)}. \tag{3}$$

The upper line in (3) pertains to symmetrical modes ($\phi(-z) = \phi(z)$) and the lower to the antisymmetrical ones. Recognizing that the modulus of the ion term in (2) does not exceed $\tau\mu(\omega_{0e}^2/\omega_{Hi}^2)(k_\perp^2/|k_z|^2)$, we obtain the sufficient conditions for stability:

$$\omega \operatorname{Im}\delta < 0, \tag{4}$$

$$n^2\mu\tau\left(1 + \frac{k_\perp^2}{|k_z|^2}\right) << \frac{\operatorname{Im} k_z^2}{k_z^2} \tag{5}$$

The largest value of $|k_z^{-2}\operatorname{Im} k_z^2|$ (on the order of unity for $|k_z| \sim b^{-1}$ is obtained when the real and imaginary components in the right side of (3) are of the order of b. With increasing $|k_z|$ the value of $|k_z^{-2}\operatorname{Im} k_z^2|$ decreases rapidly (like $|k_z^{-2}$), and therefore the small-scale perturbations ($|k_z b >> 1$) are not suppressed by the feedback.

It can be shown that when condition (4) is satisfied the feedback should exert a stabilizing influence (on perturbations having not too large a radial wave number) also in the case when when the pickups and the control electrodes are located behind the side surface of the cylinder. Buildup of Langmuir oscillations should take place when $\omega \operatorname{Im}\delta > 0$.

The stabilization method proposed above was verified experimentally with the "Ogra-II" setup - a trap with injection of fast hydrogen atoms [2]. The plasma was produced in a simple mirror field H = 10 kG, and its density was limited by flute instability at the 10^7 cm^{-3} level. Under these conditions, a cyclotron instability mode symmetrical with respect to the plane z = 0 develops, with m = 1, $k_\perp \approx 4a^{-1}$, and $k_z \sim b^{-1}$. The buildup of this mode leads leads to a strong broadening of the initially monochromatic ion spectrum, but in the presence of flute instability it does not influence the plasma density.

A diagram of the stabilization system is shown in Fig. 1. Oscillations at a frequency ω_{Hi}, where $(2\pi)^{-1}\omega_{Hi}$ = 15.5 MHz, are received with an electrostatic probe [2], amplified with

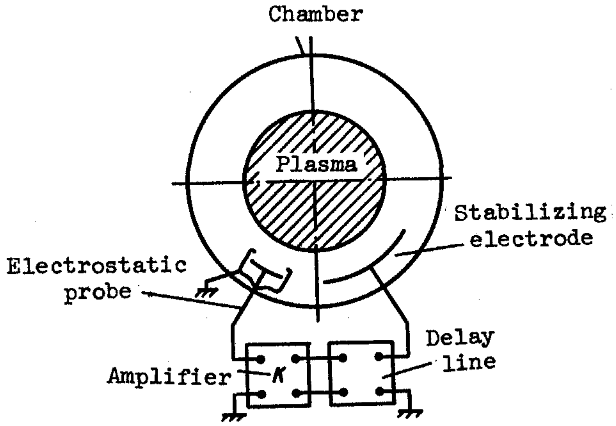
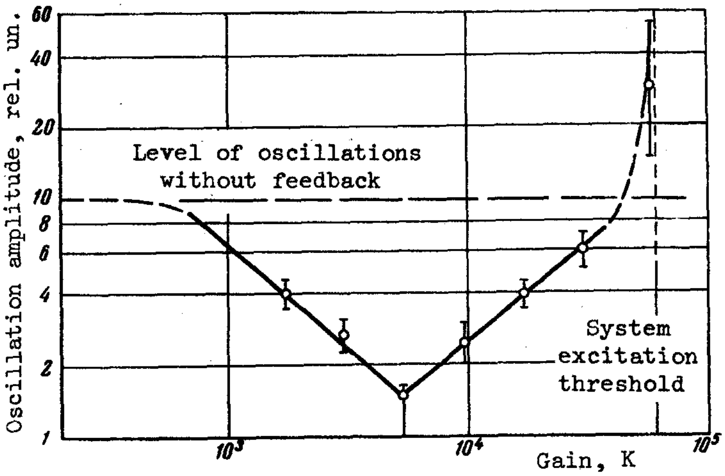


Fig. 1. Diagram of stabilizing system.

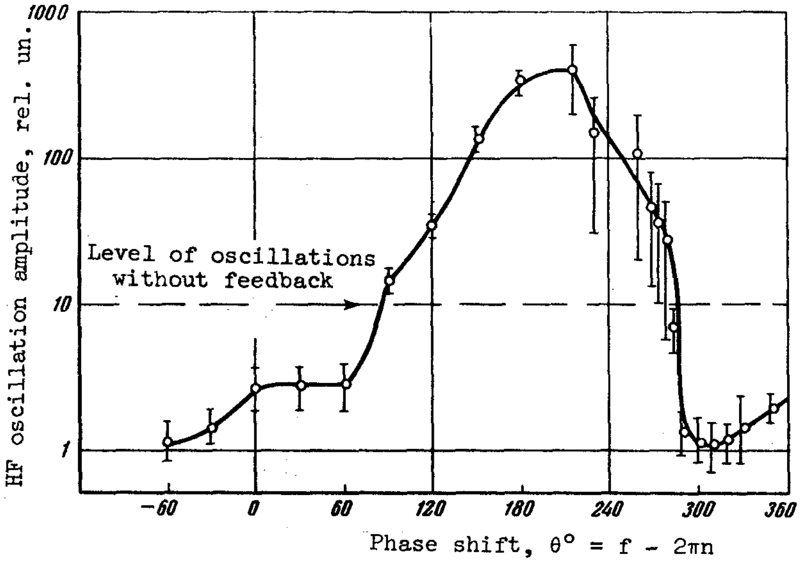
Fig. 2. Amplitude of hf oscillations vs. gain of stabilization-system amplifier (θ = 300°).



a band amplifier with a dynamic range ±15 V, delayed to obtain the required phase shift by a delay line, and fed to a stabilizing electrode of length larger than 2 m.

The experiments have shown that this system acts on the oscillations only when the gain of the amplifier lies in a certain range (see Fig. 2) and ensures, according to a rough estimate, $\delta \sim 1$. Depending on the phase shift, the amplitude of the oscillations could either decrease by one order of magnitude, or increase by almost 100 times the amplitude with the system turned off (see Fig. 3). The phase shift at which the best stabilization was observed was close to 300°. Simultaneously with the decrease of the oscillation amplitude, a sharp narrowing of the energy spectrum of the ions was observed; the latter was determined by measuring the charge-exchange neutrals [2]. These facts show that the proposed method can exert an effective influence on the cyclotron instability. Detailed experimental results will be published in subsequent papers.

Fig. 3. Amplitude of hf oscillations vs. phase shift in the stabilization system ($K = 5 \times 10^3$).



[1] A. V. Timofeev and V. I. Pistunovich, in: Voprosy teorii plazmy (Problems in Plasma Theory), No. 5, p. 351, Gosatomizdat, 1967.
[2] L. I. Artemenkov et al. Plasma Physics and Controlled Nuclear Fusion Research (Proc. of II Intern. Conf. on Plasma Physics, Culham, 1965), v. II, p. 45, IAEA, Vienna, 1966.

REGISTRATION OF A GAMMA-RAY PULSE WITH A SEMICONDUCTING DETECTOR BASED ON CADMIUM TELLURIDE

P. S. Kireev and L. I. Kalugina
Moscow Steel and Alloys Institute
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Cadmium telluride is presently regarded as the most promising material for the construction of semiconductor detectors of gamma radiation; this explains the intensive research performed on this material by many investigators. The work performed in this direction at the Moscow Steel and Alloys Institute has led to the development of p-n junctions prepared by various methods (diffusion, alloying, ion bombardment).

The junctions have low inverse currents, to 10^{-9} A at inverse voltages to 160 V, and the junction areas are on the order of 0.5 cm^2. When it was found that these junctions are sensitive to gamma radiation, we undertook an investigation of their possible use for registration of rapid processes accompanied by gamma radiation. We chose for the registration the gamma radiation produced upon deceleration, by means of a tungsten target, of electrons accelerated to 30 MeV in the linear accelerator of the Kurchatov Atomic Energy Institute; the p-n junctions were located in the gamma-ray beam. The signal induced in the junction by the incident gamma radiation was fed to a recording system that ensured high-speed sweep of the investigated signal with a two-beam oscilloscope operating in the slaved-sweep mode. One beam was used to record the signal from the investigated detector, and the other to record the comparison signal. The apparatus made it possible to superimpose sinusoidal time markers of frequency 10^8 Hz on the investigated process.

The comparison signal was obtained from a silicon gamma detector with p-i-n structure, capable of obtaining an undistorted plot of a gamma pulse with a time resolution 1 - 3 nsec. Figure 1a shows an oscillogram of the signal recorded with a CdTe detector (lower trace) and the silicon detector. Figure 1b shows similar oscillograms with time markers superimposed.

The signal was picked off a 75-ohm load resistance, with an inverse bias of 600 V applied to the silicon detector and approximately 80 volts on the CdTe detector. It can be concluded from an examination of the oscillograms that the sensitivity of the CdTe detector exceeds that of the silicon detector, and that its temporal characteristics are not worse than those of the latter. This is evidenced by the steeper leading front of the signal. The presence of a plateau on the signal from the CdTe detector is due to the fact that, owing to the relatively small inverse bias applied to the detectors, the conditions for linearity between the voltage picked off the load resistance and the gamma-ray intensity were violated, causing saturation to set in. In the case of the silicon detector, on which the bias was 600 V, the saturation occured at much higher beam intensities.

To check on this assumption, an inverse bias of 160 V was applied to the CdTe detector. As seen from Fig. 2, the form of the signal is similar to that from the silicon detector