tigation. The high luminescence efficiency of solid xenon, the absence of absorption in the region of the emission line, and the realistic values of the threshold pump power (according to estimates given in [2]) point to the possibility of attaining laser action in solid xenon excited by electrons.

[1] J. Hortner, L. Meyer, S. A. Rice, and E. G. Wilson, J. Chem. Phys. 42, 4250 (1965).
[2] A. G. Molchanov, A. I. Poluektov, and Yu. M. Popov, Fiz. Tverd. Tela 9, 3363 (1967) Sov. Phys.-Solid State 9, 2655 (1968)].

NONLINEAR ION-ACOUSTIC WAVES IN A PLASMA

S. G. Alikhanov, V. G. Belan, and R. Z. Sagdeev
Institute of Nuclear Physics, Siberian Division, USSR Academy of Sciences
Submitted 20 March 1968
ZhETF Pis'ma 7, No. 11, 405-408 (5 June 1968)

It is well known [1] that ion-acoustic oscillations can propagate in a rarefied plasma with hot electrons ($T_e \gg T_i$, where $T_{e,i}$ - electron or ion temperature). The dispersion law $\omega = \omega(k)$ for such oscillations (neglecting the weak damping) is

$$\omega^2 = \frac{4\pi n e^2}{M}\frac{k^2}{k^2+\kappa^2},$$

and in the limiting case of large wavelengths, $k \ll \kappa$ ($1/\kappa$ - Debye radius) it corresponds to an adiabatic exponent $\gamma = 1$.

Ion-acoustic waves of small amplitude in a gas-discharge plasma have been thoroughly investigated recently [2,3]. Great interest attaches to the nonlinear dynamics of the propagation of such waves, especially since a nonisothermal plasma is a typical example of a strongly dispersive medium with small absorption.

Propagation of nonlinear stable elementary waves, such as compression solitons [4-6], is possible in such a medium, and in general any initial perturbation will disintegrate in time into an aggregate of such elementary oscillations with wavelength on the order of the characteristic dispersion length (in this case the Debye radius).

We describe briefly an experiment in which we were able to trace how an initially smooth disturbance of large amplitude in a nonisothermal plasma disintegrates as a result of non-

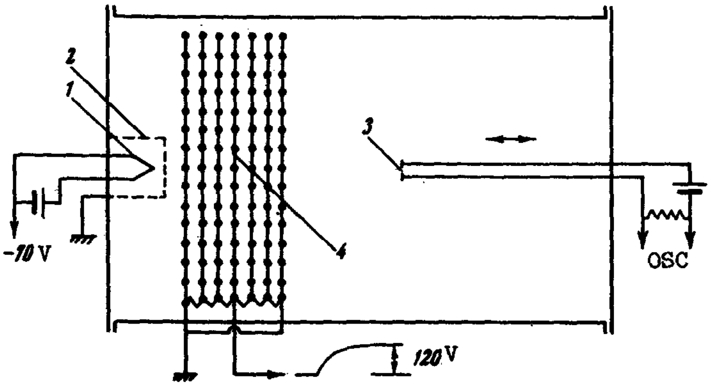

Fig. 1. Experimental setup:
1 - incandescent cathode,
2 - grid, 3 - plasma absorber,
4 - plasma source.

Linear deformation into elementary oscillations with a characteristic spatial dimension of the order of the Debye radius.

The plasma was produced in a metallic cylindrical chamber (90 cm diameter, 120 cm length) by ionization of a gas with an electron beam from an incandescent cathode ($I_c = 1$ mA). The experiments were made in the inert gases xenon, argon, and helium at a pressure $(1 - 2) \times 10^{-4}$ mm Hg. The electron temperature and density in such a plasma were determined from probe characteristics. In the experiment described, $T_e = 5$ eV and $n = 10^6$ cm^{-3}. To produce a disturbance wave in a "quiet" plasma, we used a specially developed plasma source, comprising a cylinder of 80 cm diameter and 20 cm length assembled of a series-connected flat grids [4]. A positive potential with adjustable rising front was applied to the central grid (see Fig. 1).

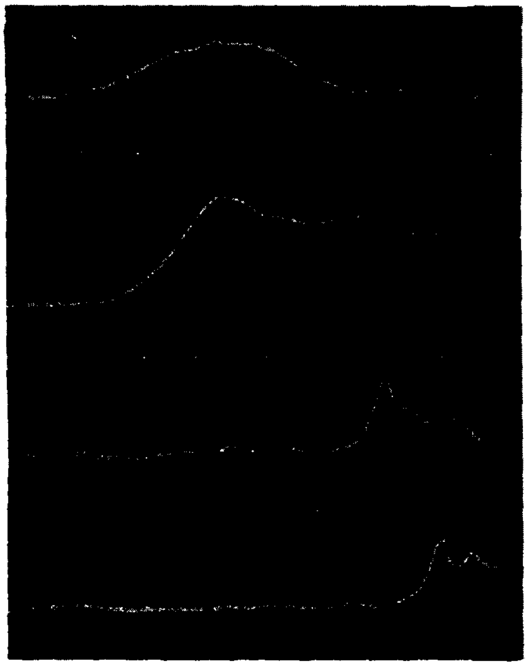

Fig. 2. Oscillograms of signals from the absorber at distances 1, 3, 12, and 19 cm from the source (reading downward in the figure). The time and density scales are respectively 20 μsec and 2×10^5 cm^{-3} per large division.

The variation of the flux in the wave was recorded with a plasma absorber consisting of a set of parallel plates installed along the direction of the wave motion. The voltage applied to the plates drew out the plasma, and a signal proportional to the current was applied to the input of a differential amplifier. The frequency characteristic of the measuring circuit was linear up to 1 MHz.

Figure 2 shows oscillograms taken at several positions of the meter, showing the evolution of the waveform in a propagating xenon plasma. The front velocity, 3×10^5 cm/sec, corresponded to a Mach number $M = 1.5$. We see that the wave propagation is accompanied by a decrease in the width of the front, down to a certain level on the order of 2 cm, approximately equal to the Debye radius. Oscillations with wavelengths on the order of the Debye radius are produced behind the front. An electrostatic probe placed perpendicular to the wave propagation revealed that the front is plane within not more than 1 cm.

[1] L. Tonks and I. Langmuir, Phys. Rev. 33, 195 (1929).
[2] I. Alexeff and R. V. Neidigh, ibid. 129, 516 (1963).
[3] I. Alexeff and W. D. Jones, Phys. Rev. Lett. 15, 286 (1965).
[4] R. Z. Sagdeev, In: Voprosy teorii plazmy (Problems of Plasma Theory), No. 4, Gosatomizdat, 1964, p. 20.
[5] V. I. Karpman, Phys. Lett. 25A, 708 (1967).
[6] C. S. Gardner, J. M. Greene, M. D. Kruskal, and R. M. Miura, Phys. Rev. Lett. 19, 1095 (1967).