Nb [3]. Finally, the temperature dependence of the static resistance of $Nb_3Sn$ contains a term proportional to $\exp(-T_0/T)$, where $T_0 \approx 80$°K, a term nonexistent for other metals [9, 13].

All these features show that the electron and phonon spectra of $Nb_3Sn$ are unusual and call for great caution when theories developed for ordinary metals are used.

In conclusion we are grateful to V.L. Ginzburg and to the participants of the seminar under his direction for a discussion of this work.

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# EXPERIMENTS ON THE CONTAINMENT OF AN ALKALI PLASMA IN A CORRUGATED MAGNETIC FIELD

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As shown in [1, 2], longitudinal containment of a dense plasma (i.e., a plasma with $\lambda < L$, where $\lambda$ is the Coulomb mean free path and $L$ is the length of the apparatus) can be greatly improved by replacing the homogeneous magnetic field by a corrugated (multiple-mirror) field. We report here the results of experiments performed to verify the plasma-containment efficiency in such a magnetic-field configuration.

The investigations were performed on a low-temperature alkali plasma, since it is easy to satisfy the condition $\lambda < L$ in it, owing to the large Coulomb cross section, and since the possibility of obtaining such a plasma by surface ionization makes it possible to regulate its parameters easily.

The vacuum chamber of the installation was a stainless-steel tube 249 cm long with inside diameter 6 cm. The chamber was evacuated by two magnetic-discharge pumps to $p \sim 2 \times 10^{-7}$ Torr.

The magnetic system consisted of 27 cooled coils of two different types. When 14 coils of one type were turned on, a multiple-mirror configuration was produced in the chamber ($H_{max} = 5400$ Oe, mirror ratio $k = 1.83$, length of individual mirror trap (probkotron) $\ell = 16$ cm). When the 13 additional coils were turned on, it was possible to change over to a homogeneous field within $\sim$0.1 sec ($H = 6400$ Oe).

The alkali metal (cesium, potassium) vapor was ionized with a tungsten disk 1.5 mm thick, heated by electron bombardment. Under typical conditions, the temperature at the center of the disk was 2400°K, and the temperature drop from the center to the edge did not exceed 7% with the magnetic field turned on. The flux of the cesium atoms[1] to the ionizer could be regulated by varying the wall temperature of the metallic container with the cesium. The container had a shutter device which made it possible, in particular, to stop the supply of cesium vapor within a time on the order of 250 μsec.

The plasma concentration n was determined with the aid of six Langmuir probes located in different throats. Each probe could be moved along the chamber radius. The probes were made of tungsten wire with average diameter 4 μ, drawn through two parallel quartz capillaries (length $\sim$6 cm, diameter 80 - 100 μ). The plane passing through the probe filament and the capillaries was perpendicular to the axis of the apparatus. The use of different probe combinations has shown that the probes do not affect the plasma parameters.

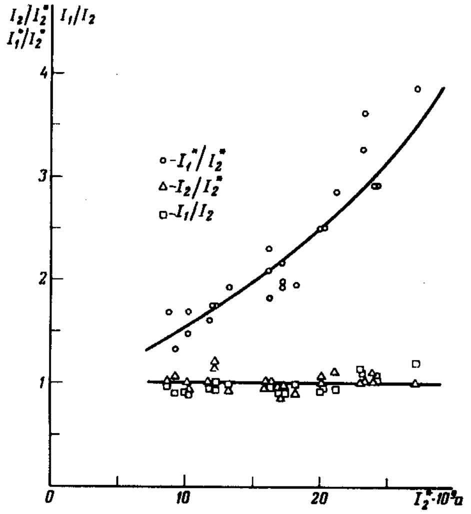

Fig. 1. Influence of magnetic-field corrugation on the longitudinal density drop. The quantities marked by asterisks pertain to the corrugated field. A current $10^{-8}$ A corresponds to a concentration $\sim 10^9$ cm$^{-3}$. The ratio $I^*_1/I^*_2$ was corrected for different probe lengths.

The experiments described below pertain to two probes (henceforth called the first and second), the distance between which was 9 throats. The second probe was located at a distance of one throat from the end of the apparatus. The length of the open part of the first probe was 5.2 mm, and that of the second 3.8 mm. The probes were made incandescent directly before each measurement. The measurements were performed with the ion current saturated at a bias greatly exceeding (by approximately ten times) the ion temperature. Under these conditions, the probe current was proportional to n and was independent of the plasma temperature.

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[1] We refer here to cesium for the sake of brevity, since the experiments with potassium gave analogous results.

The influence of the corrugation on the longitudinal plasma containment can be verified by two methods: first, by measuring directly the decay times of the plasma after a pulsed interruption in the cesium supply; second, by determining the longitudinal plasma-density drop in the stationary regime.

In the stationary measurements, the cesium flux, which varied slowly as a result of heating (cooling) of the container, was directed to the ionizer. The magnetic field was turned on at definite time intervals, and two configurations, multiple-mirror and homogeneous, were produced in sequence every time the field was turned on. The currents from the probes installed on the system axis were registered with a high-speed five-channel automatic plotter. The results of one of the experimental runs are shown in Fig. 1. The possibility of changing rapidly to a homogeneous field has made it possible to monitor the passage of the plasma along the entire system. As seen from Fig. 1, $I_1/I_2 \approx 1$, thus indicating 100% passage of the plasma in the homogeneous magnetic field. On the other hand, the near-unity value of $I_2/I^*_2$, observed in the region $I^*_2 < 2.8 \times 10^{-8}$ A, means that no plasma loss takes place when the field is corrugated. Indeed, owing to the large mean free path $(\lambda > \ell)$, the plasma density in the last probkotron mirror is determined only by the transmitted plasma stream, which in the absence of losses does not depend on the number of the probkotron and is equal to the initial flux from the ionizer. In other words, in the absence of losses the plasma density on leaving the installation should not depend on the field configuration, as was indeed observed in the experiment.

In accordance with the theory (see [3, 4]), the ratio $I^*_1/I^*_2$ should increase exponentially $(I^*_1/I^*_2 = \exp\{AI^*_2\})$ with increasing $I^*_2$ (i.e., of the density), and should subsequently decrease with increasing $I^*_2$. Our experiments confirm the presence of an exponential dependence in the region of not too high densities. From the experimentally-obtained value of the coefficient A we can estimate the ion temperature (see [3, 4]), which turns out to be 0.5 eV, a perfectly reasonable value if account is taken of the presence of a Debye layer near the ionizer, where the ions acquire a translational energy that is converted into heat in the first few probkotrons.

In the region $I^*_2 > 3 \times 10^{-8}$ A, the ratio $I^*_1/I^*_2$, according to the predictions of the theory, should decrease. Such an effect was indeed observed qualitatively in our experiments, but since we were unable to ensure complete passage of the plasma at high densities $(I^*_2 \geq 3 \times 10^{-8}$ A), the corresponding results do not admit of a unambiguous interpretation and are not presented here.

An example illustrating the results of the pulse measurements is shown in Fig. 2. In the corrugated magnetic field, the time required for the plasma

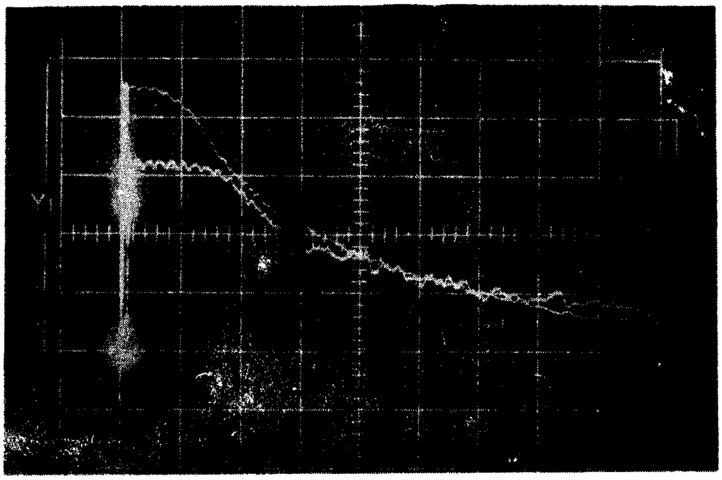

Fig. 2. Oscillograms of probe currents when the cesium flux is turned on pulse-wise. The sensitivity for the lower trace (second probe) is 2.2 times larger than for the upper one. Sweep 2 msec per division.

density to decrease to one-half is approximately 4 msec. The time of free plasma expansion in a homogeneous magnetic field under conditions corresponding to Fig. 2 turned out to be of the order of 1.5 msec. The pulse-measurement data correspond qualitatively to the predictions of the theory (see [3, 4]).

The agreement between experiment and theory indicates that the method of longitudinal plasma containment with the aid of many probkotrons is promising, since the same theory predicts that, in the problem of expansion of a plasmoid with free boundaries, which is of interest for controlled thermonuclear fusion, the use of a multiple-mirror system increases the plasma lifetime by roughly $L/\ell$ times in comparison with the case of a homogeneous field.

Note added in proof. After this article was prepared for publication, we learned of a paper by Logan et al. (Phys. Rev. Lett. 29, 1435 (1972)), in which the theory was qualitatively confirmed. However, owing to the small number of mirrors (5), and the large transverse losses, a quantitative interpretation of the results given in that paper is difficult.

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# CONCERNING ONE EXACT SOLUTION OF THE THEORY OF QUASILINEAR RELAXATION OF A PARAMETRICALLY UNSTABLE PLASMA IN THE FIELD OF POWERFUL RADIATION

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Research on parametric resonance in a plasma has stimulated a detailed development of individual aspects of the theory of such phenomena [1, 2]. Plasma heating in research on controlled thermonuclear fusion [3 - 5] or experiments with powerful radiation in the plasma near the earth [6] are but a few of the problems making the development of a theory for parametrically excited plasma pressing. In the present communication we report the first results of a quasilinear theory describing the establishment of a quasistationary state in a parametrically unstable plasma exposed to powerful radiation. The obtained self-similar solution of the system of quasilinear equations [7] makes it possible to determine the spectral density of the field fluctuations in the plasma, the electron distribution function, and the number of fast electrons arising during the course of the quasilinear relaxation in the development of parametric instability.

We consider a homogeneous plasma situated in a constant magnetic field1) and an alternating electric field (pump wave) with frequency $\omega_0$ and intensity $E_0$. We confine ourselves to a study of quasilinear evolution of parametric instability, corresponding to the decay of the pump wave into an oscillation with a frequency of the lower hybrid resonance $\omega_{Le}|\cos\theta|$, and slow magnetosonic wave $\omega_{Li}kr_{De}|\cos\theta|$ ($\theta$ is the angle between the wave vector k and the magnetic field,

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1) The results obtained here do not depend explicitly on the intensity of the external magnetic field, the role of which reduces in essence to making the quasilinear relaxation one-dimensional.