SINGULARITIES OF THE SUPERCONDUCTING TRANSITION IN PURE SINGLE-CRYSTAL TIN ACCORDING TO ULTRASONIC MEASUREMENT DATA[1)]

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It is known that in the vicinity of T_c the transition of a superconductor from the normal to the superconducting state is accompanied by a sharp decrease of the ultrasound absorption coefficient α, with an infinite value of the derivative $d\alpha/dT$ at the transition temperature. For transverse sound, in the case of large $q\ell$ (q is the wave vector of the sound and ℓ is the electron mean free path), there is also an additional drop in the absorption, due to the elimination of the inductive contribution as a result of the Meissner effect. We report here, however, experiments on the temperature dependence of the ultrasound absorption coefficient in single-crystal tin in a region adjacent to T_c, which reveal a different $\alpha(T)$ dependence, at any rate in tin.

We investigated the absorption of longitudinal and transverse sound of frequency 51.4 MHz at all possible orientations of the sound wave vector $\vec{q}$ and of the polarization $\vec{\epsilon}$ coinciding with the principal crystallographic directions. The initial material for the samples was tin with R(300°K)/R(4.2°K) = 25,000. The magnetic field was compensated to a level 3 - 5 mOe.

Figure 1 shows the most characteristic results of the measurements, obtained for transverse propagation of sound in the sample. We see that whereas at $\vec{q} \parallel [001]$ and $\vec{\epsilon} \parallel [100]$ the region of deviation of the absorption from the value corresponding to the normal state is quite negligible just before the steep drop of the absorption in the superconducting state, this region extends over a temperature interval ~0.02°K when $\vec{q} \parallel [110]$ and $\vec{\epsilon} \parallel [\bar{1}10]$. We note that a similar behavior for the aforementioned transverse modes is exhibited also by the change of the speed of sound in the vicinity of the superconducting-transition temperature. We can state with full assurance that in the region of the smooth decrease of α/α_n, which precedes the steep drop, the sample is in the superconducting state, since application of a weak magnetic field raises the quantity α/α_n to the value corresponding to the normal state.

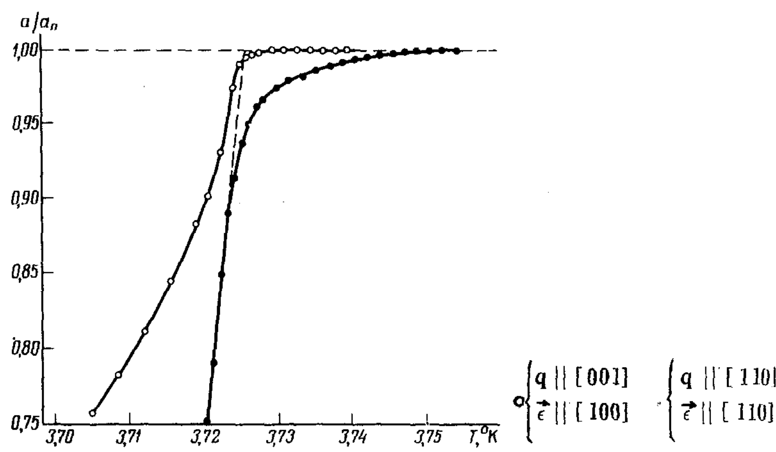

Fig. 1

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For longitudinal sound (Fig. 2), the steep drop of the absorption is also preceded by regions of a smooth decrease from a value corresponding to the normal state. It turns out therefore that within the limits of the accuracy of our measurements the recorded superconducting transition occurs for $\vec{q} \parallel$ [100] at a temperature 0.005° higher than in the case $\vec{q} \parallel$ [001]. This effect was already noted back in 1960 [1], although the term "anisotropy of T_c," used in that reference, must be recognized to be inappropriate.

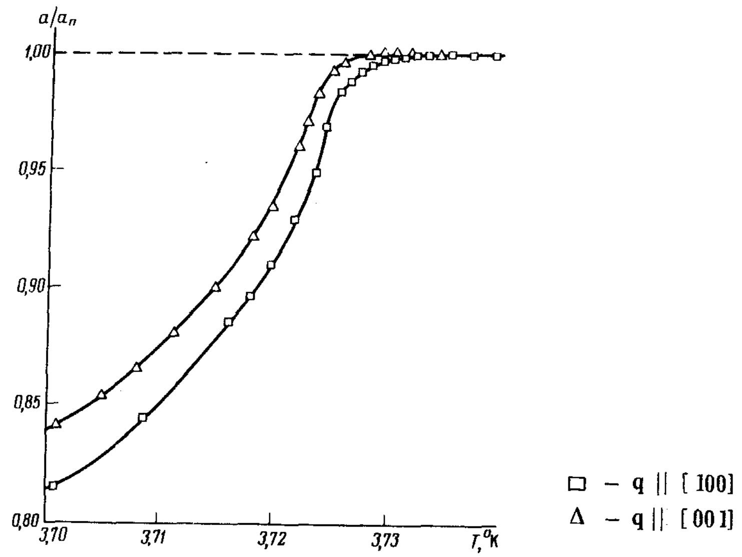
Extrapolation of the steepest section of the curves gives for all the investigated temperatures the same temperature of the "true" superconducting transition, $T_c = 3.725 \pm 0.001$°K. On the other hand, the experimental points located in the region where the sound absorption decreases smoothly above T_c are well fitted by an exponential (Fig. 3) whose argument and amplitude factor depend on the orientation of the crystallographic axes of the sample relative to $\vec{q}$ and $\vec{\varepsilon}$.

The observed effects cannot be ascribed to inhomogeneity of the sample, since a change in the character of the temperature dependence of the absorption coefficient in one and the same sample occurs not only when the direction of the sound wave vector $\vec{q}$ is changed, but also when the polarization is varied and $\vec{q}$ is kept constant. The usual thermodynamic fluctuations likewise do not explain the phenomenon, for the following reasons: a) the measured values of $\Delta\alpha/\alpha_n$ exceed the estimates by many orders of magnitude [2]; b) the dependence of $\Delta\alpha/\alpha_n$ on $(T - T_c)$ differs greatly from the square-root dependence that is typical of such fluctuations.

We point out that in pure tin, in a temperature region 0.03°K above T_c, there is also observed a diamagnetism that is anomalously large in comparison with the theory [4], and that a similar behavior of the susceptibility of gallium is reported in [4]. It is characteristic that in our experiments, just as in [4], an increase of the impurity concentration decreases the magnitude of the effect and decreases the temperature region in which it is observed.

It is possible that the reason for the observed phenomena is that tin, with its complicated Fermi surface, is a multiband superconductor. It is shown in [5] that the shift of the transition temperature of a two-band superconductor is $\Delta T_c \sim \pi\hbar/2k\tau$, where k is Boltzmann's constant and τ is the relaxation

Fig. 2



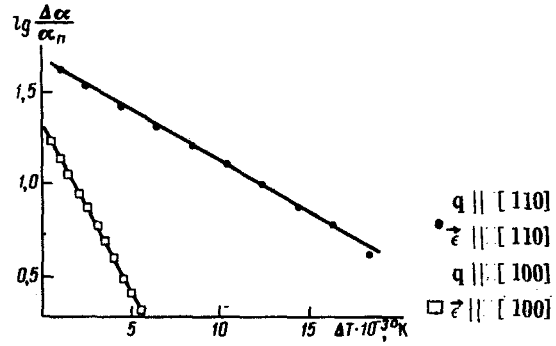


Fig. 3

time. If we assume $\tau \sim \ell/v_F$, then $\Delta T_c \sim 10^{-2}$°K. In this temperature region one cannot exclude the probable appearance of inclusions of the superconducting phase, with a lifetime $\sim\tau$, which can lead to the observed effect.

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USE OF NONSTATIONARY HOLOGRAPHY TO IMPROVE THE DIRECTIVITY OF LASER RADIATION

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It is well known that pumping produces in the interior of the laser medium inhomogeneities of the refractive index, and these distort the radiation diagram of the laser. One of the possibilities of correcting the laser radiation is to use holography methods. Thus, singly-exposed holograms were used in [1] to improve the radiation diagrams of a laser. The use of such a scheme would make it possible to compensate for static inhomogeneities, but could not correct inhomogeneities that develop in the course of time. In principle, dynamic holography [2] could be useful in this case, but the existing thermal dynamic holograms make it possible to follow only slow processes ($\sim 10^{-3}$ sec), and high powers are needed to obtain holograms on the basis of low-inertia effects.

We propose here to compensate for the inhomogeneities dynamically by using continuous holographic recording and reproduction of nonstationary optical fields (see [3, 4]). In this scheme, a special reference wave is used, and the recording is by means of a light-sensitive three-dimensional element (much progress has been made recently in the development of three-dimensional materials for holography [5]). We note that the efficacy of the proposed compensation method depends on the reproducibility of the conditions in successive cycles of laser operation.

Assume that we have an amplifier whose dielectric constant $\epsilon' - i\epsilon''$ is inhomogeneous over the cross section and varies in time. We assume that when a