The effect of the plasma mirror during the breakdown of the air inside the CO_2 laser resonator occurs when the action of several generation spikes cause the density of the plasma electrons to increase to such an extent that the reflection coefficient at the CO_2 laser frequency exceeds a certain value determined by the gain in the active medium of the laser. In our case the gain exceeded 100, and the self-excitation conditions were therefore satisfied by a very large margin at 10% reflection. Such a value of the reflection coefficient is attained already at an electron density 7×10^{18} cm^{-3}.

We note that a control experiment, during the course of which an arc discharge was struck in the focal region of the laser cavity, has shown that generation does actually occur in the laser when one of the laser mirrors is replaced by a plasmoid.

Thus, breakdown of air at atmospheric pressure by a pulse of 10-μ radiation of long duration has made it possible to observe such effects as self-modulation of the laser radiation in the pre-breakdown state and formation of a plasma mirror. The nature of these types of self-action is decisively influenced by the change of the real part of the dielectric constant of the medium under the influence of radiation from a high-power CO_2 laser.

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INVESTIGATION OF MAGNETIC FIELD EXCITED IN A METAL BY HEAT FLOW

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As is well known, stationary heat flow cannot produce a magnetic field in an ideal single crystal. However, if the structure is not ideal, as shown by the experiments described below, a field perfectly accessible to modern measurement methods can be produced in the sample.

The instrument used for the investigation is shown in Fig. 1a. The magnetic field was measured with a superconducting magnetic flux quantum meter (SMFQM) analogous to that described by Zimmerman [1]. As is well known, the SMFQM makes it possible to measure a magnetic flux up to 10^{-10} Oe-cm^{-2}. In the experiment, the setup was adjusted in such a way that the heaters H_1 and H_2 drew equal amounts of power. In this case, on switching from H_1 to H_2, the state of a sample located under the coupling loop would change only if heat flow were present.

The first object of the investigation was chosen to be tin. The samples were made of metal of highest purity. The thermal conductivity of the sample at T_c was ~50 W-cm^{-1}deg^{-1}. A typical SMFQM chart is shown in Fig. 1b. H_1 and H_2 designate which of the heaters is turned on, G indicates when the current is

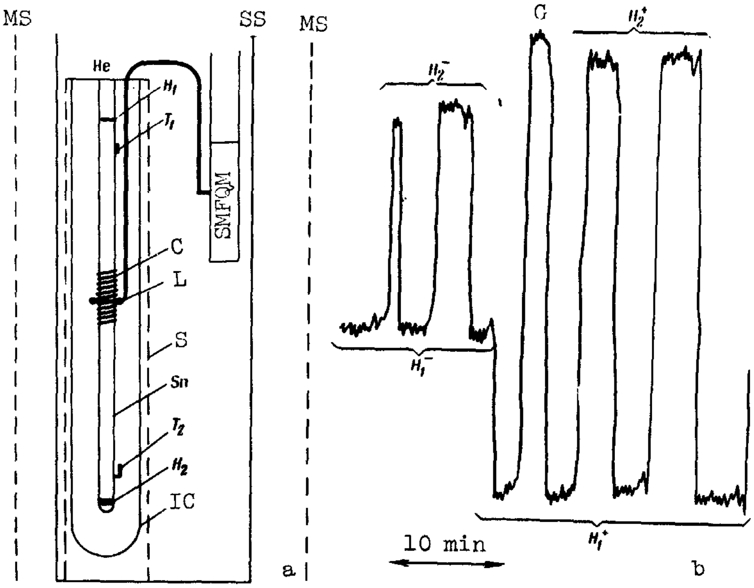

Fig. 1. a) Instrument for the measurement of the magnetic field: Sn - investigated sample, T_1, T_2 - carbon thermometers, H_1, H_2 - heaters, C - field calibration coil, L - loop for coupling with SMFQM, IC - chamber for thermally insulating the sample from the helium, S - superconducting lead solenoid, SS - superconducting screen, MS - permalloy magnetic screen. b) Typical SMFQM chart, explanation in the text.

turned on in the field-graduation coil and corresponds in this chart to 10^{-5} Oe in the cross section of the sample, while the plus and minus signs mark the direction of the current through the heater. All the measurements were performed in both current directions, so as to eliminate the parasitic effect due to the magnetic field of the heaters.

It is seen clearly on the chart that turning on a heat flux q causes a change ΔH in the magnetic field of the sample. The value of ΔH, within the limits of measurement accuracy, was directly proportional to the heat flux q, both in the normal and in the superconducting state (Fig. 2). When the direction of q is reversed, the direction of ΔH is also reversed. Additional experiments performed at $T < T_c$ have shown that ΔH is directed along the sample axis.

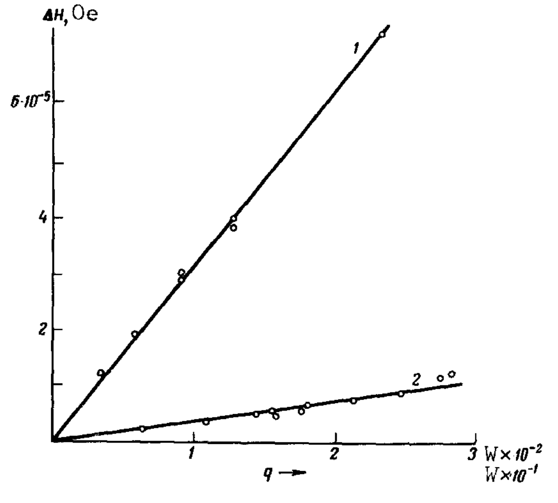

Fig. 2. Excited magnetic field vs. heat flux along the sample. 1) T = 4.2°K (Sn 5), 2) T = 3.5°K (Sn 3). The upper and lower scales of q pertain to curves 1 and 2, respectively.

The ratio $\Delta H/q = H_q$ is practically constant in the normal state (3.7 - 4.2°K) and then H_q decreases sharply at T_c by almost two orders of magnitude, after which, in the interval 3.5 - 2.5°K, it decreases only insignificantly (Fig. 3a). An external magnetic field up to 1 Oe does not affect the value of H_q, and usually the experiments were performed in fields $\lesssim 10^{-2}$ Oe. In the superconducting state, ΔH exceeded the field produced when the sample temperature was changed from 2.5 to 3.5°K, while the temperature gradient along the sample did not exceed 0.02°K.

It is clear from symmetry considerations that a magnetic field proportional to the heat flux can be directed along the sample axis if the distortions

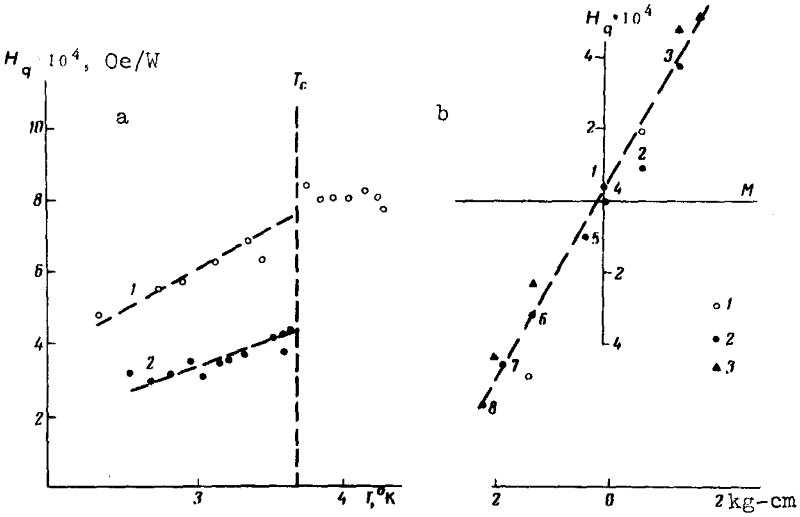

Fig. 3. a) Temperature dependence of H_q: 1 - Sn 5, 2 - Sn 3. The scale of H_q decreases by a factor of 20 at $T = T_c$. b) Dependence of H_q on the torque applied to the sample: 1, 2 - Sn 5, 3 - PB 1. $H_{q,M=0}$ for curves 1, 2, and 3 are respectively equal to +8, -3.5, and -2×10^{-4} Oe/W. The numbers designate the sequence of the measurements in one of the experiments. The deformation at the maximum load was ~0.1 deg/cm for tin and 0.4 deg/cm for lead.

of the crystal-structure homogeneity have axial symmetry. Such distortions are produced by torsion deformations. Accordingly, we investigated experimentally the influence of torsion deformation on the value of H_q. It turned out that such a deformation alters H_q significantly. At loads M below a certain critical value M_{cr} ($M_{cr} \approx 2$ kg/cm for samples of 5 mm diameter) H_q depends on M in a reversible fashion (Fig. 3b). When the load is $\tilde{>} M_{cr}$, the value of H_q begins to depend irreversibly on M, and when the load is removed the value of H_q of the sample may remain appreciable. The plots of Fig. 3a were obtained with such samples. A jumplike increase of H_q at M_{cr} was observed for a tin sample grown along the [101] direction.

The appearance of a magnetic field in the presence of heat flow is apparently not limited to tin. In the case of both tin and lead the value of H_q is sensitive only to the torsion deformation of the sample. A longitudinal load up to 25 kg/cm² does not change H_q within the limits of the measurement accuracy.

The totality of the obtained data apparently indicates that heat flow in a sample with a crystal structure distorted by inhomogeneous deformation leads to the occurrence of a magnetic field. This field appears because the electron energy and velocity in the deformed lattice depend on the deformation (see, e.g., [2]), and a circular component of the currents appears in a lattide distorted by torsion, as apparently first noted by A.F. Andreev[1]. One of the

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[1] Private communication.

possible reasons for the presence of H_q in a superconductor may be that the superconducting and normal current components fail to cancel each other. The question of the appearance of such currents in a superconductor with a temperature gradient was considered in [3].

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THE PROBLEM OF THE $K_L \rightarrow 2\mu$ DECAY AND μ-MESIC ATOMS

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As a possible explanation why the $K_L \rightarrow 2\mu$ decay has not been experimentally observed, it has been recently suggested that a nonelectromagnetic interaction between muons and hadrons is possible [1 - 4] (a list of earlier papers can be found in the reviews [5 - 7] and in [8]). We discuss here the limitations that can be obtained from data on μ-mesic atoms for the constants g_i of the four-fermion muon-nucleon interaction:

$$g_i \bar{N} O_i N \bar{\mu} O_i \mu , \qquad (1)$$

where

$$i = S, V, T, A, P; \; O_S = 1, \; O_V = \gamma_\mu, \; O_T = \sigma_{\mu\nu}, \; O_A = \gamma_\mu \gamma_5, \; O_P = \gamma_5 .$$

We assume for simplicity that the nucleon current in (1) is isoscalar.

We consider three effects: the shift and the fine and hyperfine splitting of the levels. The first effect is sensitive to the S and V interactions, the second to the S interaction, and the last to A, T, and P interactions.

If $g_{S,V} \neq 0$, then the nuclear radius R_e determined from data on electron scattering and the nuclear radius R_μ determined from the positions of the mesic-atom levels should differ by an amount

$$R_\mu^2 - R_e^2 = 6A(g_V + g_S)/4\pi\alpha Z , \qquad (2)$$

where A and Z are the atomic number and the charge of the nucleus, and $\alpha = 1/137$. A summary of the experimental data on R_μ and R_e can be found in Table 3 of [6]. Within the limits of errors, $R_e = R_\mu$ for all the nuclei for which measurements were performed.

R_e is known with better accuracy than R_μ, for light nuclei, and with worse accuracy for heavy ones. Therefore the best upper bound is obtained from data on medium nuclei. For example, for aluminum $R_e \simeq R_\mu = 3$ F and $(R_\mu - R_e)/R_e < 1.3\%$. We can therefore conclude that

$$g_V + g_S < 4 \cdot 10^{-2} \text{GeV}^{-2} . \qquad (3)$$