$(\Delta\nu \sim 10^{-2}\ \mathrm{cm}^{-1})$1).

The anti-Stokes shift observed by us experimentally in the laser-emission spectrum turned out to be larger by approximately one order of magnitude than the estimate value (Fig. 2). In the spectrum of the back-scattered light we observed only the laser emission. It is interesting that the shifted diffuse band (Fig. 2) was observed even at low xenon concentrations $c \approx 3 \times 10^{-3}$. It did not appear in pure helium up to 10 atm and in xenon up to 0.5 atm (the breakdown did occur in this case). At $c \approx 0.1$, a shift $\Delta\nu \approx 0.09 - 0.07\ \mathrm{cm}^{-1}$ of the band maximum was observed, and at $c \approx 2 \times 10^{-2} - 1 \times 10^{-2}$ the shift was $\Delta\nu \approx 0.120\ \mathrm{cm}^{-1}$.

The observed values of the broadening of the laser line can be apparently explained by assuming again that excited xenon atoms with noticeably large polarizability are produced in the interaction volume [4].

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TEMPERATURE DEPENDENCE OF THE CRITICAL CURRENT IN ALLOYS WITH A RIGIDLY PINNED VORTEX LATTICE

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To explain the superconducting properties of alloys containing finely dispersed non-superconducting particles, a model of a rigidly pinned vortex lattice was proposed in [1]. In the present paper we show that a direct consequence of the model of [1] is an unusually rapid growth of the density of the critical current j_c with decreasing temperatures. This growth does not fit in the framework of the existing theories [2, 3]. The indicated conclusion has been confirmed experimentally.

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1) In our case the registration of the process of the spectrum broadening could occur only at increasing radiation intensity [3], since the plasma produced upon breakdown is practically opaque to the laser light.

In the case of rigid pinning of the vortices [1], the dependence of j_c on the external magnetic field is described by the expression

$$i_c = \frac{H_c}{4\pi\lambda}\left(1 - \frac{H}{H_{c2}}\right)^2, \tag{1}$$

where H_c, H_{c2} and H are the thermodynamic, second critical, and external magnetic fields, and λ is the effective depth of penetration. We derive from (1) a connection between j_c and temperature for two cases:

$$1)\ h = H/H_{c2} = \text{const}; \quad 2)\ H = \text{const}.$$

In case 1) we have

$$i_c^{(t)} = A^2(H_c(t)/4\pi\lambda(t)), \tag{2}$$

where $A = 1 - h$ does not depend on the temperature, and $t = T/T_c$. As is well known [4, 5],

$$H_c(t) = H_c(0)(1 - t^2) \tag{3}$$

$$\lambda(t) = \lambda_0(1 - t^4)^{-1/2}. \tag{4}$$

The presence of finely dispersed non-superconducting particles in the alloy makes it necessary to take into account the proximity effect - the diffusion of the superconducting pairs into the normal metal over a distance on the order of the coherence length $\xi(t)$. From the relation

$$\pi\xi^2(t) = \phi_0/H_{c2}(t), \tag{5}$$

where ϕ_0 is the magnetic-flux quantum, and from the experimentally established relation for the alloys investigated in the present paper

$$H_{c2}(t) = H_{c2}(0)(1 - t^2), \tag{6}$$

which is typical of most superconducting alloys, we obtain:

$$\xi(t) = \xi(0)(1 - t^2)^{-1/2}. \tag{7}$$

Since the dimensions of the particles and the distance between them are of the order of $\xi(t)$, the superconducting volume is proportional in first approximation to $\xi^3(t)$. Consequently, the concentration of the superconducting pairs, which enters in λ_0, equals

$$n_{s0} = n_{s0}(0)(1 - t^2)^{3/2}. \tag{8}$$

Taking (8) into account, the dependence (4) takes the form

$$\lambda(t) = \lambda_0(0)(1 - t^2)^{-5/4}(1 + t^2)^{-1/2}. \tag{9}$$

Then

$$i_c(t) = \frac{H_c(0)}{4\pi\lambda_0(0)}A^2(1 - t^2)^{9/4}(1 + t^2)^{1/2}. \tag{10}$$

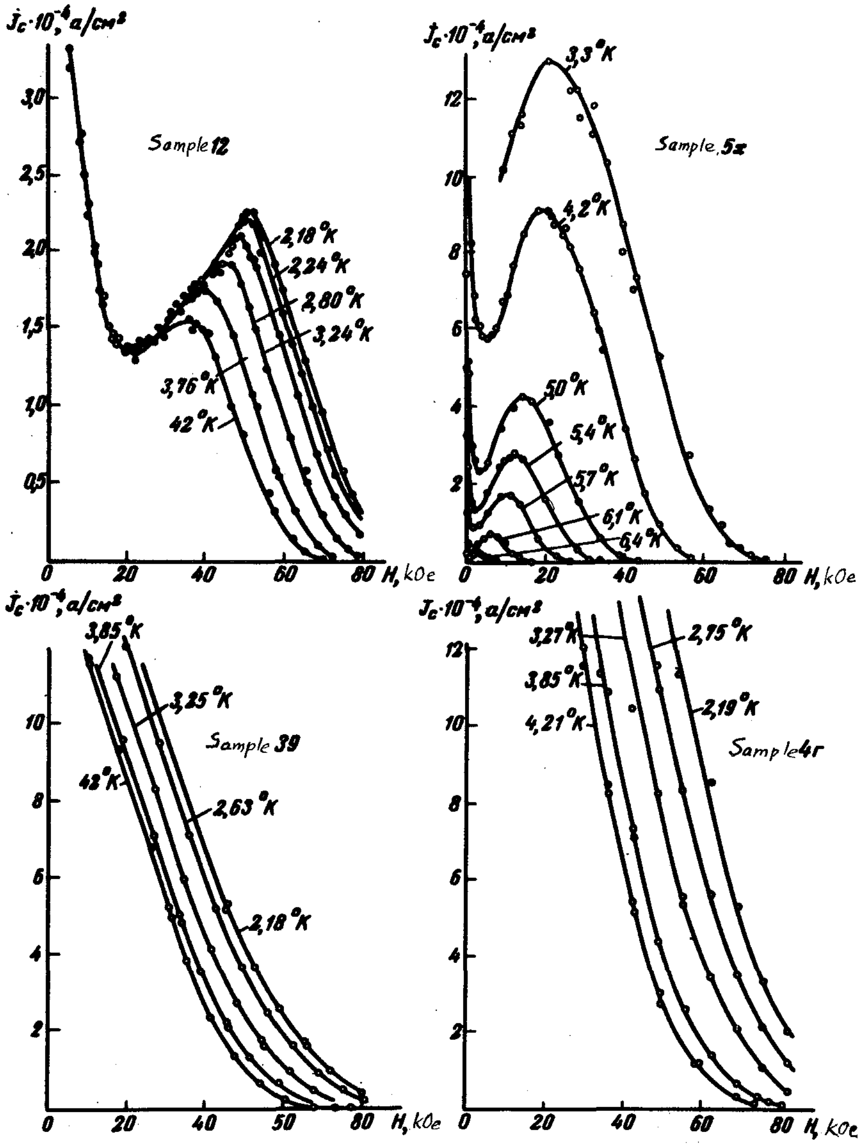

Fig. 1. Critical-current density vs. external transverse magnetic field at various temperatures; the sample properties are listed in the table.

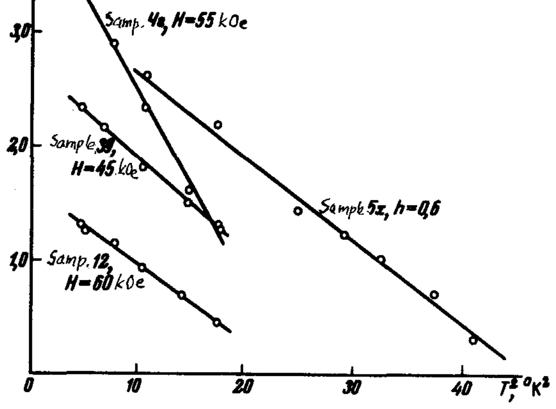

Fig. 2. Comparison of the experimental results of Fig. 1 with formulas (11) and (12).

Alloy composition	Sample No.	Sample dia.mm	Heat treatment
Ti + 22 at.% Nb	5X	0.24	Quench from 800° (1 hr), temper 390° (1 hr)
Ti + 22 at.% Nb	5Г	0.24	Quench from 800° (1 hr), temper 390° (3 hr)
Zr + 20 at.% Nb	12	0.22	Quench from 800° (1 hr), temper 350° (3 hr)
Zr + 20 at.% Nb	39	0.25	Quench from 800° (1 hr), temper 450° (3 hr)

Comparison of (10) with the experimental data simplifies greatly if the temperature-dependent term is approximated with the aid of the function $(1 - t^2)^2$. The error arising in this case (see formulas (11) and (12)) does not exceed 3% in the temperature region $0 \le t < 0.9_0$. We have

$$[i_c(t)]^{1/2} = [\frac{H_c(0)}{4\pi\lambda_0(0)}]^{1/2} A(1 - t^2). \qquad (11)$$

Thus, if the model of rigid pinning of the vortex lattice is correct, the dependence of $[j_c(c)]^{1/2}$ on t^2(or T^2) should be linear at h = const.

Case 2). A similar temperature dependence occurs if the measurements are made at H = const. Taking formulas (3), (6), and (9) into account and using the previous approximation, we obtain

$$[i_c(t)]^{1/2} = [\frac{H_c(0)}{4\pi\lambda_0(0)}]^{1/2} \frac{H_{c2}(0)(1 - t^2) - H}{H_{c2}(0)}. \qquad (12)$$

An experimental verification of relations (11) and (12) was made with samples made of alloys Ti + 22 at.% Nb and Zr + 20 at.% Nb. The measurement procedure is described in [1], and the parameters of the samples and the heat-treatment conditions are listed in the table.

To investigate the temperature dependence of λ_c (Fig. 1), we chose two types of samples - with an without peaks on the $j_c(H, T)$ curves. The "peak effect" was observed at small aging times, when the particles of the ω phase segregated in the matrix [1] have superconductivity of the inclusions. In fields beyond the maximum, the vortex lattice is rigidly pinned. The curves without the peak effect were obtained for samples subjected to a more prolonged or a more high-temperature aging, as a result of which the ω particles were greatly enriched with titanium (or zirconium) and did not become superconducting, thus ensuring rigid pinning of the vortices in the entire investigated range of values of H and T.

Figure 1 shows clearly the strong growth of the critical currents with decreasing temperature. A comparison of the experimental results with formulas (11 and (12) is shown in Fig. 2. For samples 4g, 12, and 39, the dependence of $[j_c(T)]^{1/2}$ on T^2 has been constructed for constant values of the external magnetic field intensity. For the sample 5kh, the same dependence was constructed at constant $h = H/H_{c2}$. We see that in both cases the dependence is linear.

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