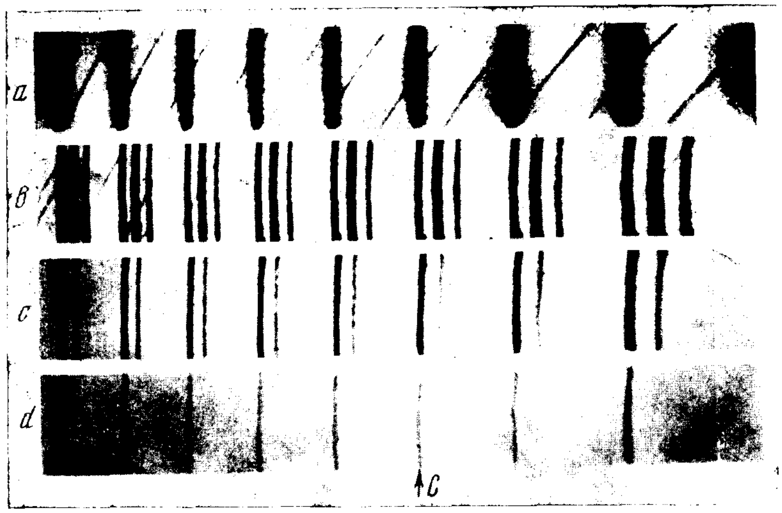
Interference pattern of light scattered by benzene at a scattering angle θ = 90°. Fabry-Perot interferometer dispersion region 1 cm^{-1}. a - ruby laser emission spectrum; b - spectrum of light scattered by benzene (θ = 90°) at a ruby laser power 90 MW focused in the cell by a 2.5-cm lens; c and d - the same with the laser emission intensity decreased by factors 2.6 and 6, respectively. C - central component produced in STS.



ponding to θ = 180° by the intensified "temperature wave." If this is so, then several STS components are seen in the figure directly.

There was the danger that possible inhomogeneities produced in the liquid in the laser focus (such as cavitation) might spread the exciting light and this might mask the STS. We therefore performed an experiment with methanol, whose hydrodynamic characteristics are such that benzene occupies an intermediate position between it and water. Nonetheless, in accord with the small value of $|(\partial\varepsilon/\partial T)_p|$ and γ, the intensity of the central component in scattering at an angle θ = 90° was smaller in methanol than in benzene, and vanished when the laser emission intensity dropped by a factor of six. At this attenuation, the central component was still observed in benzene.

The described experiments thus convince us that we have observed STS in benzene.

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*We are considering plane waves, the process is assumed to be stationary, and the pulse duration is much longer than the temperature settling time. If second sound can propagate in the medium, the solutions obtained are different and are similar to those for usual SMBS.

**During the performance of this work we observed several side effects which are still under study at present.

RESISTANCE OF A THIN SUPERCONDUCTING CURRENT CARRYING FILAMENT

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1. The influence of temperature fluctuations on the smearing of current in a superconducting junction was noted by Pippard [1]. In recent investigations [2,3] this problem was

considered for a thin filament and for a thin film. It was proposed in all the investigations that the energy dissipation sets in only when some microscopic volume of the superconductor goes over into the normal state as a result of fluctuations. In light of the ideas advanced in [4], this is incorrect, for apparently a situation is possible wherein a superconducting condensate as well as an electric field coexist simultaneously.

We are considering the resistance of a thin superconducting current-carrying filament without a magnetic field, with allowance for the temperature fluctuations.

2. Consider first the current transition in a superconducting filament without allowance for the fluctuations. We shall show that even at a current $j > j_c$ the filament resistance does not return to normal (under conditions of ideal heat removal). In spite of the rough nature of the calculation, it can be assumed that its results are applicable to the problem of fluctuation resistance of the filament. A rigorous solution of the current transition of a thin filament from the superconducting to the normal state requires, of course, a separate study and the use of microtheory methods.

We consider a thin filament with radius $r \ll \delta_0/\kappa$, $\delta_0(T)$ is the depth of penetration of a weak magnetic field, and κ is the constant of the Ginzburg-Landau theory [5]. All the conditions needed for the validity of the theory of [5] are assumed to be satisfied.

What processes will occur in the thin superconducting filament if an external source is used to increase the current density in it to a value larger than j_c? When $j = j_c$ we still have $F_s < F_n$, where F_s and F_n are the free-energy densities in the superconducting and normal states, respectively. Therefore there should be no phase transition in the usual sense of this word at $j = j_c$. However, the transport of an electric current with the aid of superconducting electrons only is impossible, since there are not enough of the latter for this purpose [5, 6]. We now use the idea advanced in [4] concerning the mechanism whereby the energy is dissipated in the transition region near the core of the Abrikosov vortex, and extend it to include the case of a thin superconducting filament.

When $j > j_c$, an electric field E is produced in the filament, and accelerates the condensate during the time τ that the superconducting state relaxes, from a velocity v_d (corresponding to the critical current j_c) to a velocity $v_d + (eE/m)\tau$. After the end of this time, the Cooper pairs making up the condensate break up into individual electrons that relax with the lattice and slow down to a velocity smaller than v_d. They are then again paired and fall into the condensate (since $F_s < F_n$), and the entire process begins anew. Bearing in mind this picture and taking into account the existence of a normal component of the electron liquid, we can readily obtain an expression for the effective resistivity of the filament $j > j_c$:

$$R = \sigma^{-1}(1 - j_c/j), \tag{1}$$

where $\sigma = \sigma_n + (c^2\tau/6\pi\delta_0^{\,2})$, and σ_n is the conductivity in the normal state. Thus, the restoration of the resistance of a thin filament when $j > j_c$ should take place not with a jump at $j = j_c$, but slowly and monotonically. This, of course is valid only under conditions of ideal heat removal. The foregoing reasoning holds also for a thin film. The stretching of the current transition in thin films was observed experimentally (see [7]).

3. We now take into account the influence of the temperature fluctuations. We consider first the case $j < j_c$. Assume that at some place in the filament the temperature fluctuations have increased. The density of the superconducting electrons $|\psi|^2$ is therefore decreased at this place. If it drops below a certain threshold value (for the given current j), then, in accordance with Sec. 2, an electric field is produced at this place and energy dissipation begins. For dissipation to begin in our case it is therefore not necessary that ψ vanish as a result of the fluctation. In other words, a local fluctuation resistance R_L appears, given by formula (1), in which j_c is already determined by the locally raised temperature.

To determine the effective resistivity R it is necessary to average the random quantity R_L with the aid of the distribution function for the fluctuations. Calculation has shown that the fluctuations of ψ have a normal distribution with a variance

$$D = \frac{m\delta_0}{2\sqrt{3}\hbar^2 S\kappa} \cdot \frac{kT}{\sqrt{C_v/\Delta C}}, \tag{2}$$

where S is the cross section area of the filament, k is Boltzmann's constant, C_v is the specific heat, and ΔC is the jump in the specific heat in a second-order phase transition at the critical temperature T_c.

Averaging over this distribution function gives a smooth increase of R with increasing j (with $j < j_c$). The region near j_c in which the role of the fluctuations is significant is given by the formula (we assume that $C_v \sim \Delta C$)

$$\frac{j_c - j}{j_c} \sim 60 \frac{ke^2}{(\hbar c)^2} \frac{\delta_0^3 T}{\kappa S}. \tag{3}$$

When $j = j_c$, the effective resistance turns out to be

$$R \sim \frac{1}{\sigma} \frac{3e}{\hbar c} \frac{\delta_0^{3/2}\sqrt{kT}}{\sqrt{\kappa S}}.$$

If $T \sim 10^\circ$K, $\kappa \sim 1$, $\delta_0 \sim 10^{-5}$ cm, and $S \sim 10^{-12}$ cm^2, then $(j_c - j)/j_c \sim 10^{-2}$ and $R(j_c) \sim 3 \times 10^{-2}\sigma^{-1}$.

In the case when $j > j_c$ there is superimposed on the resistance given by (1) an increment due to the temperature fluctuations. This additional resistance decreases rapidly with increasing $j - j_c$. The region of currents in which this increment is appreciable is given by

$$\frac{j - j_c}{j_c} \sim \frac{10e}{\hbar c} \frac{\sqrt{\kappa S}}{\delta_0^{3/2}\sqrt{kT}}.$$

At the same filament characteristics we get $(j - j_c)/j_c \sim 0.1$.

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