EFFECT OF EXTERNAL FLUCTUATIONS ON THE PROPERTIES OF SUPERCONDUCTING MICROJUNCTIONS NEAR CRITICAL TEMPERATURE

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The effect of voltage fluctuations in the external circuit on the volt-ampere characteristic of a superconducting microjunction near T_c is investigated. At temperatures exceeding the critical value, voltage fluctuations weaken superconductivity induced by fluctuation pairing. Stimulation of superconductivity is possible on the negative part of the volt-ampere characteristic below T_c. It is shown that fluctuations introduced from the external circuit reduce the critical temperature of the microjunction.

To describe correctly the properties of superconductors at temperatures close to critical, it is necessary to take into account the fluctuation pairing and unpairing of electrons resulting from thermodynamic fluctuations in the superconductor and from voltage fluctuations coming from the external circuit. For bulky samples, the fluctuation pairing of the electrons is significant in a very narrow temperature region near T_c, on the order of 10^{-4}–10^{-15} deg[1]. For samples having a small parameter $d \ll \xi_0$ (ξ_0 is the coherence length), the temperature interval in which the thermodynamic fluctuations are significant increases[2]. From the microscopic theory developed by Aslamazov and Larkin[3] it follows that allowance for fluctuation pairing above T_c leads to the appearance of increments to the electric conductivity, to the specific heat, and to the sound-absorption coefficient in the metal, which diverge at $T = T_c$, and alters significantly other dynamic and static characteristics of the superconductor.

Another mechanism of fluctuation pairing above T_c was proposed by Maki[4]. Maki took into account, in first order, the contribution made to the electric conductivity by the interaction of the Cooper pairs with the background of the normal electrons. In the three-dimensional case, this contribution is finite, but in the two-dimensional case it diverges logarithmically. As shown by Thompson[5], the presence of a weak interaction that lowers T_c makes Maki's expression finite in the two-dimensional case, and a large disordering interaction suppresses it. The electron-electron and electron-phonon interactions produce too small a shift of T_c to explain the experimental results[6-8]. The change of T_c can be due also to paramagnetic impurities in the film and to imperfections in its structure.

We shall show below that the shift of T_c may be connected with voltage fluctuations in the external electric circuit. Such fluctuations will also distort the current-voltage characteristic of the film. The voltage fluctuations introduced into the film from the external circuit lead to the need for statistically averaging the nonlinear current-voltage characteristic of the fluctuation current (which is due to the fluctuation pairing of the electrons) with a certain distribution function. At temperatures above T_c, the nonlinear current-voltage characteristic of the film was calculated by Schmid[9] (see also[10]). With increasing field intensity E on the film, the superconducting component of the current j first increases linearly, but then takes the form $j \propto E^{1/3}$. For films in the resistive state below T_c, as shown by Gor'kov[11] and by Kulik[12], j decreases with increasing E, reaches a minimum, and then again takes the form $j \propto E^{1/3}$. From an elementary analysis it follows that under voltage fluctuations with small amplitude, the current at a given E can either increase or decrease, depending on the sign of the second derivative $j''(E)$. If $j''(E) > 0$, then the current increases and in this sense one can speak of stimulating superconductivity by external fluctuations. For $j''(E) < 0$, the superconducting component of the current decreases, i.e., the superconductivity is suppressed. The expression obtained for the current in[9,11,12] is

$$j = \frac{e^2 T E}{2\pi d|\Gamma|}\int_0^\infty d\lambda \exp\left(-\lambda \operatorname{sign}\Gamma - \left(\frac{E}{E_c}\right)^2 \frac{\lambda^3}{3}\right), \quad (1)$$

where $\Gamma = 8\pi^{-1}(T - T_c)$, $E_c = 2|\Gamma|/e\xi(T)$, and $\xi(T)$ is the temperature-dependent coherence length.

It is seen from relation (1) that above T_c we have $j''(E) < 0$ at all values of E, and below T_c we have $j''(E) > 0$ if $E < E_0$ and $j''(E) < 0$ for $E > E_0$ ($E_0 \approx 2E_c/9$). Consequently, for $T > T_c$ the superconductivity is suppressed by the voltage fluctuations and, as will be shown below, a noticeable lowering of T_c is possible under definite conditions.

1. Tsuzuki[13] confirmed microscopically the procedure proposed by Schmid[9] of using the Ginzburg-Landau time-dependent equation[14], supplemented with a fluctuation term

$$\frac{\partial\psi}{\partial t} + \Gamma\left(1 - \frac{|\psi|^2}{\psi_0^2}\right)\psi - D\left(\nabla - \frac{2ie}{c}\mathbf{A}\right)^2\psi = S(\mathbf{r}, t), \quad (2)$$

with

$$\overline{S(\mathbf{r},t)} = 0, \qquad \overline{S(\mathbf{r},t)S(\mathbf{r}',t')} = 0,$$
$$\overline{S(\mathbf{r},t)S^*(\mathbf{r}',t')} = 4mTDd^{-1}\delta(\mathbf{r}-\mathbf{r}')\delta(t-t').$$

Here ψ_0 is the ordering parameter in the absence of an electromagnetic field and fluctuation pairing, $D = v_0 l/3$ (v_0 is the Fermi velocity and l is the mean free path of the electrons), and d is the film thickness. We assume a film of length L in the direction of the x axis, situated in a constant electric field $E = Ei$. The voltage fluctuations lead to the appearance of a potential difference $U(t)$ between the points $x = 0$ and $x = L$. The vector potential $A(t)$ can be chosen in the form[1)]

$$A(t) = -ic\left[Et + \frac{1}{L}\int_0^t d\tau U(\tau)\right]. \quad (3)$$

In order to find the connection between $A(t)$ and the field outside the film, it is necessary to supplement Eq. (2) with the boundary conditions for $\psi(r, t)$ and the corresponding Kirchhoff equation. We shall not be interested, however, in a solution of the external problem.

The solution of Eq. (2) without allowance for fluctuation pairing ($S(r, t) = 0$) was obtained by Gor'kov and Eliashberg[15]. Since the spatial dependence of the vector potential is not taken into account, ψ is independent of the coordinates in this approximation, and thus

$$f(t) = -\frac{1}{2|\Gamma|}\frac{\partial}{\partial t}\ln\left\{\frac{1}{f_0} - 2\Gamma\int_0^t dt_1 \exp\left(-2\int_0^{t_1} d\tau\left[\Gamma + \frac{4e^2}{c^2}DA^2(\tau)\right]\right)\right\}$$
$$= -\frac{1}{2\Gamma}\frac{\partial}{\partial t}\ln F(t), \quad (4)$$

where $f(t) = |\psi|^2/\psi_0^2$, and f_0 is the value of f at $t = 0$. Let us calculate the average value of the square of the ordering parameter and the current in a film acted upon by an alternating electric field with frequency Ω. In this case

$$-\frac{2e}{c}A(t) = P_0 + P_1 \sin\Omega t, \quad P_1 = \frac{2eU_0}{L\Omega}i,$$

P_0 is the "superfluid" momentum. The time-average value of $f(t)$ is calculated from the formula

$$\bar{f} = \lim_{t\to\infty}\frac{1}{t}\int_0^t dt_1 f(t_1) = 1 - \xi^2(T)\left[P_0^2 + \frac{P_1^2}{2}\right] \quad (5)$$

Here $\xi^2(T) = D/|\Gamma|$. Expression (5) coincides with the condition, obtained in[15], for the independence of the solution (4) of the initial conditions. It is seen from (5) that an alternating voltage reduces the critical temperature of the film:

$$T_c' = T_c - \frac{\pi}{16}DP_1^2. \quad (6)$$

The superconductivity is destroyed if the specified voltage is larger than the critical value U_{0c}:

$$U_{0c} = \Omega L/\sqrt{2}e\xi(T). \quad (7)$$

The critical value of the current in the film is obtained by calculating the average value of the current:

$$\bar{j} = \frac{2e}{m}[P_0\bar{f} + \overline{P_1 f(t)\sin\Omega t}] = \bar{j}' + \bar{j}''$$

at the extremal value of P_0. The expression for the critical current consists of two parts: $j_c = j_c' + j_c''$. The current j_c' was calculated by Kulik[16]:

$$j_c' = j_{c0}(1 - P_1^2\xi^2/2)^{3/2}, \quad (8)$$

where j_{0c} is the critical value of the current in the absence of an alternating field. The increment j_c'' appears upon averaging of the oscillating part of the potential with the time-dependent value $f(t)$; it can be either positive or negative. For $\bar{f} \ll w = \Omega/2|\Gamma|$ we have

$$j_c'' = j_c'\frac{P_1^2\xi^2}{w}\frac{I_1(P_1^2\xi^2/w)}{I_0(P_1^2\xi^2/w)}. \quad (9)$$

For $P_1^2\xi^2/w \ll 1$ we have

$$j_c'' = -j_c'P_1^2\xi^2\bar{f}/(\bar{f}^2 + w^2) \quad (10)$$

From formula (4) we see that at a constant voltage on the film the value of f tends to zero as $t \to \infty$, but it is finite for finite times. Allowance for the fluctuation pairing causes the ordering parameter to differ from zero in the resistive region. Linearizing Eq. (2) with respect to the fluctuation increment $\psi_1(r, t)$ ($\psi = f^{1/2} + \psi_1$), we obtain an equation for $\psi_1(r, t)$:

$$\frac{\partial\psi_1}{\partial t} + \left[\Gamma - D\left(\nabla - \frac{2ie}{c}A\right)^2\right]\psi_1 - \Gamma f(2\psi_1 + \psi_1^*) = S(r, t). \quad (11)$$

Here $A(t)$ is determined by formula (3).

Changing over to the Fourier representation, we obtain for the mean value of the current, after averaging over $S(r, t)$,

$$j(t) = \frac{8eDT}{dL_1L_2}\sum_k\int_0^t dt_1[(\eta_t + \varphi_t)i + k_y j]\exp\{-2\Gamma(t - t_1)$$
$$-2D\int_{t_1}^t d\tau[(\eta_\tau + \varphi_\tau)^2 + k_y^2]\}\left\{\frac{F_{t_1}^3}{F_t^3} + \frac{F_{t_1}}{F_t}\right\}, \quad (12)$$

where L_1 and L_2 are the dimensions of the film in the directions y and z, k is the two-dimensional wave vector, and

$$\eta_t = k_x + 2eEt, \quad \varphi_t = \frac{2e}{L}\int_0^t dt_1 U(t_1).$$

In order to exclude transient processes from consideration, it is necessary to change over to the limit $t \to \infty$ in expression (12) after averaging over the random quantity φ_t.

We consider first the case $\varphi_t = 0$. Then, changing from summation with respect to k to integration in accordance with the rule

$$\sum_k = \frac{L_1L_2}{(2\pi)^2}\int dk,$$

we reduce expression (12) to the form

$$j = \frac{e^2TE}{4\pi d|\Gamma|}\int_0^\infty d\lambda \exp\left\{-\lambda\,\mathrm{sign}\,\Gamma - \frac{\varepsilon^2\lambda^3}{3}\right\}\{G^3(\lambda) + G(\lambda)\}, \quad (13)$$

where $\epsilon = E/E_c$ and

$$G(\lambda) = \lim_{t\to\infty}\frac{F(t)}{F(t + \lambda/2|\Gamma|)}. \quad (14)$$

From the definition (4) it is seen that the integral in $F(t)$ depends little on the upper limit at large values of t. Therefore

$$G(\lambda) = 1.$$

Expression (13) then goes over into (1). Thus, allowance for the ground state of the superconductor in first order does not exert any influence on the fluctuation increment to the current.

2. Let us now take into account the influence of the external fluctuations with arbitrary spectrum. To find

1)It is assumed that the dimensions of the microjunction are such that the spatial dependence of $A(t)$ can be neglected. This means that the noise spectrum should be cut off at frequencies $\omega \ll c/L$.

the current averaged over the voltage fluctuations, it is necessary to calculate the quantity

$$N=\left\langle(\eta_t+\varphi_t)\exp\left\{-2D\int_{t_1}^{t}d\tau(\varphi_\tau^2+2\varphi_\tau\eta_\tau)\right\}\right\rangle, \tag{15}$$

where $\langle\ldots\rangle$ denotes averaging over the random quantity φ_t. We assume that φ_t has a normal distribution[17]

$$P[\varphi_\tau]=\exp\left\{-\frac{1}{2}\int_{t_1}^{t}d\tau\,d\tau_1 B_{\tau\tau_1}\varphi_\tau\varphi_{\tau_1}\right\}, \tag{16}$$

with the kernel $B_{\tau\tau_1}$ connected with the correlation function

$$\Psi_{\tau\tau_1}=\langle\varphi_\tau\varphi_{\tau_1}\rangle \tag{17}$$

by the relation

$$\int_{t_1}^{t}ds B_{\tau s}\Psi_{s\tau_1}=\delta(\tau-\tau_1). \tag{18}$$

Using the distribution (16), expression (15) can be written in the form

$$N=\frac{1}{\mathscr{D}}\int D[\varphi_\tau]P[\varphi_\tau](\eta_t+\varphi_t)\exp\left\{-2D\int_{t_1}^{t}d\tau(\varphi_\tau^2+2\varphi_\tau\eta_\tau)\right\}; \tag{19}$$

Here $\mathscr{D}=\int D[\varphi_\tau]P[\varphi_\tau]$, where $D[\varphi_\tau]$ is the functional differential.

We introduce a new distribution function

$$P_1[\varphi_\tau]=\exp\left\{-{}^1/_2\int_{t_1}^{t}d\tau d\tau_1 C_{\tau\tau_1}\varphi_\tau\varphi_{\tau_1}\right\}, \tag{20}$$

where

$$C_{\tau\tau_1}=B_{\tau\tau_1}+4D\delta(\tau-\tau_1). \tag{21}$$

Using relation (20), we obtain after simple transformations

$$N=\left(\eta_t-\frac{1}{4D}\frac{\delta}{\delta\eta_t}\right)\frac{1}{\mathscr{D}}\int D[\varphi_\tau]P_1[\varphi_\tau]\exp\left\{-4D\int_{t_1}^{t}d\tau\varphi_\tau\eta_\tau\right\}.$$

The integral in the numerator of this expression can readily be evaluated

$$N=\left(\eta_t-\frac{1}{4D}\frac{\delta}{\delta\eta_t}\right)\exp\left\{8D^2\int_{t_1}^{t}d\tau\,d\tau_1\eta_\tau\eta_{\tau_1}M_{\tau\tau_1}\right\}\frac{\mathscr{D}_1}{\mathscr{D}},$$

$$\mathscr{D}_1=\int D[\varphi_\tau]P_1[\varphi_\tau].$$

The kernel $M_{\tau\tau_1}$ is the inverse of $C_{\tau\tau_1}$:

$$\int_{t_1}^{t}dsM_{\tau s}C_{s\tau_1}=\delta(\tau-\tau_1). \tag{22}$$

Using Eqs. (18), (21), and (22), we obtain an integral equation for $M_{\tau\tau_1}$:

$$M_{\tau\tau_1}+4D\int_{t_1}^{t}dsM_{\tau s}\Psi_{s\tau_1}=\Psi_{\tau\tau_1}. \tag{23}$$

It remains to calculate the quantity

$$\exp F(D)=\mathscr{D}_1/\mathscr{D},\qquad F(0)=0.$$

Differentiating this ratio with respect to the parameter, we obtain

$$\frac{\partial F}{\partial D}=-\frac{2}{\mathscr{D}_1}\int_{t_1}^{t}d\tau\int D[\varphi_\tau]P_1[\varphi_\tau]\varphi_\tau^2. \tag{24}$$

To calculate (24) it is convenient to introduce the characteristic functional $\Phi[k_\tau]$ of the normal distribution function $P_1[\varphi_\tau]$:

$$\Phi[k_\tau]=\exp\left\{-\frac{1}{2}\int_{t_1}^{t}d\tau\,d\tau_1k_\tau k_{\tau_1}M_{\tau\tau_1}\right\}$$

$$=\frac{1}{\mathscr{D}_1}\int D[\varphi_\tau]P_1[\varphi_\tau]\exp\left\{i\int_{t_1}^{t}d\tau\varphi_\tau k_\tau\right\} \tag{25}$$

From (25) it follows that

$$\langle\varphi_\tau^2\rangle=-\frac{\delta^2}{\delta k_\tau^2}\Phi|_{k=0}=M_{\tau\tau}.$$

Hence

$$\partial F/\partial D=-2\int_{t_1}^{t}d\tau M_{\tau\tau},\qquad F=-2\int_0^D dD\int_{t_1}^{t}d\tau M_{\tau\tau}. \tag{26}$$

Substituting the obtained value of N in (12) and recognizing that $G(\lambda)=1$, we get

$$\langle j(t)\rangle=\frac{e^2T\mathbf{E}}{\pi d}\int_0^t dt_1[(t-t_1)\mathscr{M}_2]^{-1/2}\left\{2\left(t-4D\int_{t_1}^{t}d\tau M_{t\tau}\tau\right)\right.$$

$$\left.-\left(1-4D\int_{t_1}^{t}d\tau M_{t\tau}\right)\frac{\mathscr{M}_1}{\mathscr{M}_2}\right\}\exp\left(-\left\{2\Gamma(t-t_1)+2\int_0^D dD\int_{t_1}^{t}d\tau M_{\tau\tau}\right.\right.$$

$$\left.\left.+2De^2E^2\left[\frac{4}{3}(t^3-t_1^3)-16D\int_{t_1}^{t}d\tau\,d\tau_1\tau\tau_1M_{\tau\tau_1}-\frac{\mathscr{M}_1^2}{\mathscr{M}_2}\right]\right\}\right)$$

$$\mathscr{M}_1=t^2-t_1^2-8D\int_{t_1}d\tau\,d\tau_1\tau M_{\tau\tau_1},$$

$$\mathscr{M}_2=t-t_1-4D\int_{t_1}d\tau\,d\tau_1M_{\tau\tau_1} \tag{27}$$

Let us calculate the current-voltage characteristic for two forms of the external-fluctuation spectrum, which are of practical interest.

a) Low-frequency fluctuations. This case is realized if the spectrum is bounded by a maximum frequency w_{max} much lower than the reciprocal times of significance in (27), $w_{max}t_{eff}\ll 1$. Then

$$\Psi_{\tau\tau_1}=\left(\frac{2eU_0}{L}\right)^2\tau\tau_1=\Psi_0\tau\tau_1, \tag{28}$$

where U_0 is the effective voltage of the noise source. The integral equation (23) with kernel (28) can be easily solved:

$$M_{\tau\tau_1}=\frac{\Psi_{\tau\tau_1}}{1+{}^4/_3D\Psi_0(t^3-t_1^3)}. \tag{29}$$

Substituting the solution (29) into (27) and taking the limit as $t\to\infty$, we obtain

$$\langle j\rangle=\frac{e^2T\mathbf{E}}{2\pi d|\Gamma|}\int_0^\infty\frac{d\lambda}{[1+\lambda^3/Q^3]^{1/2}}\exp\left(-\left\{\lambda\operatorname{sign}\Gamma+\frac{\varepsilon^2\lambda^3}{3[1+\lambda^3/Q^3]}\right\}\right), \tag{30}$$

where $Q=2|\Gamma|/(\frac{1}{3}D\Psi_0)^{1/3}$.

The condition of applicability of the low-frequency approximation can be deduced from the integral (30): w_{max} should be much smaller than the larger of the two quantities $2|\Gamma|$ and $(D\Psi_0/3)^{1/3}$. It is interesting that relation (30) can also be obtained by statistically averaging the initial current-voltage characteristic (1) with a normal distribution:

$$W(U)=\frac{1}{\sqrt{2\pi U_0^2}}\exp\left(-\frac{U^2}{2U_0^2}\right).$$

We see therefore that the low-frequency approximation corresponds to adiabatic change of the fluctuation voltage, at which there is realized, at each instant of time, the usual current-voltage characteristic connected with the fluctuation pairing. Since $T < T_c$, the current in the absence of voltage fluctuations diverges exponentially at small E ($j(E) \sim \exp(2E_c/3E)$ [11,12]), and formula (30) leads to a divergent expression for the mean value of the current. This means that the use of the linear approximation below T_c in the presence of low-frequency fluctuations is not more legitimate even at finite E. If $T = T_c + 0$, then the fluctuation conductivity σ', as seen from (30), is finite:

$$\sigma' = 0.93\frac{e^2T_c}{\pi d}\left(\frac{3}{D\Psi_0}\right)^{1/3}. \tag{31}$$

The infinite jump of conductivity at the point $T = T_c$ should not be given any physical meaning.

There is no shift of the critical temperature as a result of the low-frequency fluctuations, inasmuch as the adiabatic averaging of the current-voltage characteristic does not lead to additional unpairing. The results of a numerical calculation of the current-voltage characteristic in terms of the coordinates

$$J_1 = \langle j\rangle \Big/ \frac{\sqrt{3}e^2TE_c}{2\pi d|\Gamma|\sqrt{Q}}$$

and $\mu = \epsilon^2Q^3/3$ at the different values of Q are given in Fig. 1.

b) "White" noise. The correlation function for "white" noise is

$$\langle U(t)U(t_1)\rangle = a\delta(t-t_1). \tag{32}$$

In the case when the "white" noise represents thermal fluctuations introduced from the outer circuit, we have $a = 2R_1T_1$, where R_1 and T_1 are the resistance and temperature of the external circuit. A correlator of the type (32) corresponds to noise with unlimited spectrum, and the solution (12) is suitable only in the case when $w \ll c/L$. However, if it is recognized that in the integral (12) cutoff occurs at times on the order of $[T - T_c(U)]^{-1}$, then the approximation (32) can be used for $[T - T_c(U)] \ll c/L$.

It follows from (32) that

$$\Psi_{\tau\tau_1} = C[\tau + \theta(\tau-\tau_1)(\tau_1-\tau)], \quad C = a(2e/L)^2, \tag{33}$$

$\theta(x)$ is the usual step function. Equation (23) with kernel (33) becomes a Volterra equation with a difference kernel. Its solution takes the form

$$M_{\tau\tau_1} = \frac{C}{b}\left[\frac{\operatorname{sh} b(\tau-t_1) + bt_1 \operatorname{ch} b(\tau-t_1)}{\operatorname{ch} bu + bt_1 \operatorname{sh} bu}\operatorname{ch} b(t-\tau_1) + \theta(\tau-\tau_1)\operatorname{sh} b(\tau_1-\tau)\right] \tag{34}$$

where $b^2 = 4DC$ and $u = t - t_1$.

After simple but rather cumbersome transformations we obtain

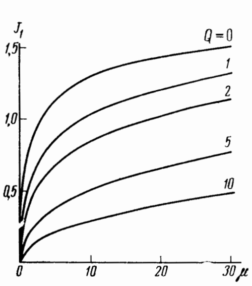

FIG. 1

$$\langle j\rangle = \frac{e^2TE}{\pi d|\Gamma|}\sqrt{q}\int_0^\infty \frac{d\lambda}{\sqrt{\lambda}}\frac{[1-e^{-2\lambda/q}]^{1/2}}{[1+e^{-2\lambda/q}]^{3/2}}\exp\{-\lambda(\operatorname{sign}\Gamma + q^{-1} + \varepsilon^2q^2)\} \times \exp\left(\varepsilon^2q^3\frac{1-e^{-2\lambda/q}}{1+e^{-2\lambda/q}}\right); \tag{35}$$

Here $q = 4|\Gamma|/b$.

The fact that the conductivity of the microjunction at $E = 0$ is finite in a certain region $T < T_c$ can be treated as a lowering of T_c. The new value of T_c will be close to the temperature T_c' at which the integral (35) diverges for $E = 0$:

$$T_c' = T_c - \pi b/32.$$

At temperatures lower than T_c', the film goes over into the resistive state at an electric field intensity above E_c',

$$E_c' = \frac{b}{2e\xi}\sqrt{1-\frac{1}{q}}. \tag{36}$$

We note that without voltage fluctuations, the resistive state below T_c is realized formally at arbitrary E [11 12]. The limitation on E is due only to the fact that the linear approximation is not valid, so that the result for $j(E)$ is actually valid only if j is not too close to the critical value of the current. The occurrence of a certain E_c' in the presence of fluctuations indicates that the linear approximation is violated at larger E than in the absence of fluctuations, i.e., this corresponds to stimulation of superconductivity.

Figure 2 shows the current-voltage characteristic of a film with external fluctuations ($J_2 = \langle j\rangle/(e^2TE_c/\pi d|\Gamma|\sqrt{q})$, $v = \epsilon^2q^3$) at different values of q.

We note that the applicability of the results is determined to a considerable degree by the experimental conditions. If the external circuit used in the experiment satisfies the quasistationarity conditions, then the spectrum of the noise introduced into the microjunction will be cut off in natural fashion at the characteristic frequencies of the circuit. The latter, as a rule, are smaller than the reciprocal relaxation time of the ordering parameter. In this case Eq. (2) is valid and, as seen from the results, a lowering of T_c occurs. On the other hand, if the quasistationarity conditions are violated or the junction is irradiated by an external microwave source, then, as shown by Eliashberg[18], an inverse effect is possible, owing to the nonequilibrium distribution of the electronic excitations at sufficiently high frequencies ($w \sim 10^{10}$ Hz).

The lowering of the critical temperature under the

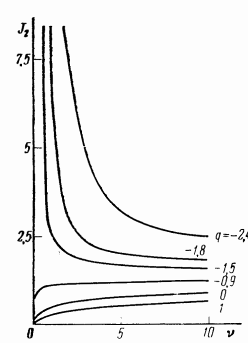

FIG. 2

action of thermal fluctuations can be discernible. Thus, for a microjunction of length $L \sim 10^{-3}$ cm and at a circuit resistance $R_1 \sim 1$ ohm we have $(T_c - T_c')/T_c \sim 10^{-1}$ in a pure superconductor ($l \sim 10\ \xi_0$) and $(T_c - T_c')/T_c \sim 10^{-3}$ for a very dirty superconductor ($l \sim 10^{-7}$ cm). It is of interest to compare the fluctuation conductivity at T_c with the conductivity σ in the normal state. For the parameters indicated above we have $\sigma'/\sigma \sim 1$ in a dirty metal and $\sigma'/\sigma \sim 10^{-2}$ in a pure one. It is seen from the foregoing estimates that the influence of the external fluctuations can be appreciable, and they carry much stronger effects on pure superconductors.

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