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UPPER CRITICAL FIELD OF A SUPERCONDUCTOR NEAR ANDERSON TRANSITION

Edward.Z.KUCHINSKII, Michael.V.SADOVSKII

Institute for Electrophysics, USSR Academy of Science, Ural Branch, Sverdlovsk, 620219, USSR.

We analyze the temperature dependence of the upper critical field of a superconductor which is close to Anderson metal-insulator transition, taking into account the magnetic field on the generalized diffusion coefficient. Some important deviation from usual behavior of "dirty" superconductors and the complete picture of Hc2(T) for different degrees of disorder up to localization region are obtained. Magnetic field effects upon diffusion are especially important for Hc2 behavior of a superconductor within the localization region.

The main results of the usual the theory of "dirty superconductors"[1,2], in particular those for the upper critical field $H_{c2}(T)$, must be essentially changed for the mean-free paths *l* of the order of inverse Fermi momentum p_F^{-1}[3].

Standard analysis of superconducting transition in the external magnetic field leads to the following equation determing $H_{c2}(T)$:

$$\mathrm{Ln}\frac{T}{T_c} = \pi T \sum_{\varepsilon_n}\{(|\varepsilon_n|+\pi D_2(2|\varepsilon_n|)\frac{H}{\Phi_0})^{-1}-|\varepsilon_n|^{-1}\}$$

where $\Phi_0=\pi c/e$ is magnetic flux quantum, Tc-transition temperature in the absence of magnetic field, $\varepsilon_n=2\pi T(n+\frac{1}{2})$, $D_2(\omega)$-generalized "diffusion coefficient" in Cooper channel[4]. $D_2(\omega)$ can be calculated using the self-consistent theory of localization with two relaxation kernels[4], taking into account the absence of time-reversal invariance and the magnetic field influence upon diffusion.

In metallic phase at small disorder such that normal-state conductivity $G \gg G^* \sim G_c(p_F\xi_0)^{-1/3}$, where $G_c=e^2p_F/\pi^3h^2$ is Mott's "minimal metallic conductivity", $\xi_0=0.18hv_F/T_c$, the $H_{c2}(T)$ behavior is like in the usual "dirty superconductor" [2] (curves 1,2 in Fig.1).

Near the Anderson transition, for $G \ll G^*$, $H_{c2}(T)$ behavior changes [3] (curves 4,5,6 in Fig.1). Positive curvature of $H_{c2}(T)$ curve appears close to Tc and inflexion point moves to lower T as disorder grows.

At the Anderson transition itself, neglecting the magnetic field influence upon diffusion, we get: (curve 6 in Fig.1 and 2 at the insert)

$$H_{c2}=m\frac{\Phi_0}{\pi}\begin{cases}\frac{(4\pi T)^{2/3}}{c_1}E^{1/3}\mathrm{Ln}\frac{T_c}{T} & T\sim T_c\\ (\frac{\pi}{\gamma}T_c)^{2/3}E^{1/3}(1-\frac{2}{3}c_2(4\gamma\frac{T}{T_c})^{2/3}) & T\ll T_c\end{cases}$$

where $c_1=4.615$, $c_2=0.259$, $\gamma=1.781$, E-is Fermi energy.

The usual Gorkov's relation [1] for $(\frac{dHc2}{dT})_{Tc}$ becomes invalid. The slope of $H_{c2}(T)$ becomes independent of conductivity [3]:

$$-\frac{1}{N(E)}(\frac{dHc2}{dT})_{Tc}=\frac{2\pi}{c_1}\frac{\Phi_0}{(N(E)T_c)^{1/3}}$$

where N(E) is the density of state at

the Fermi level.

The ratio $-H_{c2}(0)/Tc(\frac{dHc2}{dT})_{Tc}$ grows from the standard value of 0.69 to 1.24 at the mobility edge [3].

The influence of magnetic field upon diffusion is relatively small concerning the $H_{c2}(T)$ behavior at the mobility edge. Only for $T<T^*\simeq 0.02Tc$ the $H_{c2}(T)$ curve becomes convex and take the form:

$$H_{c2}=m\frac{\Phi_0}{\pi}(\frac{\pi}{\gamma}Tc)^{2/3}(\frac{E}{1+\varphi})^{1/3}(1-\frac{4\gamma}{3\varphi^{1/3}(1+\varphi)}\frac{T}{Tc})$$

where $\varphi=0.18$.

The ratio $-H_{c2}(0)/Tc(\frac{dHc2}{dT})_{Tc}$ changes to 1.18.

Superconductivity may persist even in Anderson insulator until the localization length R_{loc} is large enough so that [3]:

$$\frac{1}{N(E)R^3_{loc}} \ll Tc \qquad (*)$$

However in dielectric phase the magnetic field influence upon diffusion is much more important and under the condition (*) H_{c2} at $T \ll Tc$ destroys localization and makes the system metallic, so that the curves of $H_{c2}(T)$ in "dielectric phase" are between the curves 1 and 2 at the insert in Fig.1. Neglecting the magnetic field influence upon diffusion, we get diverging $H_{c2}(T)$ for $T \to 0$ (curve 3 at the insert in Fig.1).

CONCLUSIONS

The influence of magnetic field upon diffusion is relatively small concerning the $H_{c2}(T)$ behavior at the mobility edge. However in dielectric phase this influence is much more important. H_{c2} at $T \ll Tc$ destroys localization and makes the system metallic.

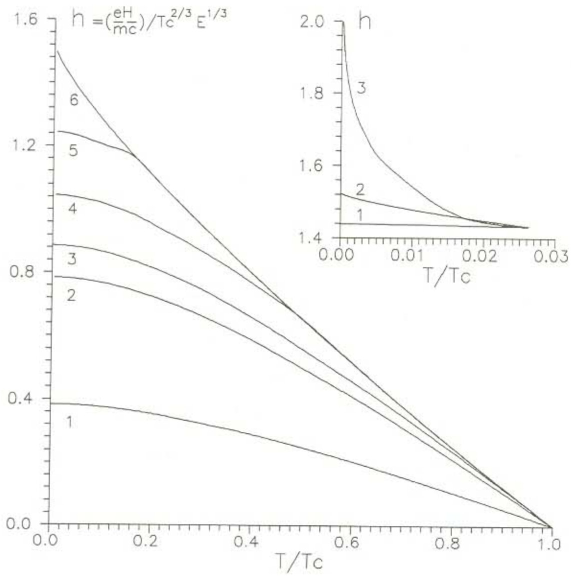

FIGURE 1
Temperature dependence of Hc2 for different values of G/G*(disorder):1. 2.5; 2. 1.2; 3. 1.0; 4. 0.8; 5. 0.5; 6. 0.0

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