CONCERNING THE DESTRUCTION OF SUPERCONDUCTIVITY WITH DIRECT CURRENT

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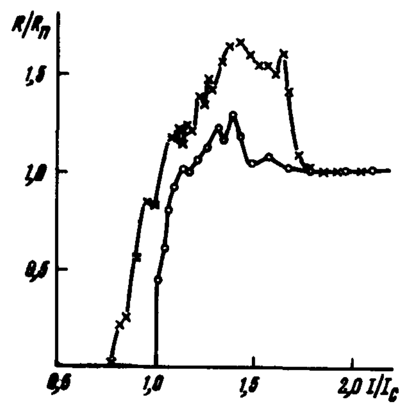
Experimental data on the destruction of superconductivity with direct current, for cylindrical samples with resistivity $\rho < 10^{-8}$ ohm-cm, do not agree with the known London formula [1] even if Joule heat is taken into account [2]. This discrepancy can be related apparently with the fact that, according to Kuper [3], an additional contribution to the resistance is produced on going to the intermediate state by the scattering of conduction electrons from the separation boundaries between the normal and superconducting regions.

If the mean free path in a sample in the normal state exceeds the periodicity of the structure of the intermediate state, then the resistance of the sample in the intermediate state can turn out to be larger than R_n. It is obvious that this defect is easier to observe in a transition from the normal state into the superconducting state, for in this case the overheating of the sample will be minimal.

We have undertaken to observe this effect experimentally. The measurements were made with single-crystal unstressed samples of tin with residual resistivity 2×10^{-4} and 2×10^{-5} ($L = 25$ mm, $d = 0.7 - 1.13$ mm), in the temperature interval $3.678 - 3.698$°K by the current method [4], with accuracy to 5×10^{-11} ohms.



Transition curve of one of the samples ($L = 25$ mm, $d = 1.13$ mm),

● - transition from superconducting to normal state

x - transition from normal to superconducting state

The figure shows one of the series of curves of the transition from the superconducting into the normal state and the inverse transition, for a sample with $\rho = 2 \times 10^{-9}$ ohm-cm at $T_B = 3.683$°K. The observed effects turn out to be appreciable - the resistance in the intermediate state exceeds R_n by 25 - 30% in the direct transition and by 65 - 70% in the inverse transition (in individual cases by 90%). The difference in the effect in the direct and inverse transitions can be attributed to the influence of the Joule heat. As can be seen from the figure, a nonmonotonic change in the resistance exists, besides the described effect, for a smooth variation of the current, apparently in analogy with the effect previously observed earlier by Galkin, Kan, and Lazarev [5].

No increase in R_n in the intermediate state was observed for tin samples with residual resistance 3×10^{-3}, but the variation of the resistance was likewise nonmonotonic.

It can be assumed that the described effect makes it possible to determine the fine structure of the intermediate state when superconductivity is destroyed with direct current.

[1] D. Shoenberg, Superconductivity, Cambridge University Press, 1952.

[2] S. Ya. Berkovich and G. M. Lapir, JETP 44, 1329 (1963), Soviet Phys. JETP 17, 896 (1963).

[3] C. G. Kuper, Phil. Mag. 43, 1264 (1952).

[4] Ya. S. Kan and L. B. Kabukhin, PTE No. 2, 192 (1965).

[5] Galkin, Kan, and Lazarev, JETP 20, 865 (1950)

NEUTRONIZATION OF He^4

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As is well known, at high densities, when the electron energy becomes sufficient for the inverse β process, the neutronization reaction begins in matter [1]. The first step in the investigation of the kinetics of this process was made by Frank-Kamenetskii [2]. During the time of the collapse of a star, owing to the neutronization of matter, only high-energy neutrinos will be emitted and these may be experimentally detectable. In an earlier note [3] we considered the process of collapse with neutronization of cold hydrogen. Estimates for other elements were extremely crude. An estimate under the assumption of an annual collapse of ten stars in our galaxy with masses 2 - 3 times the sun's mass yielded a high-energy neutrino flux (10 - 30 MeV) amounting to several per cent of the solar flux (the neutrino from B^8 decay, with maximum energy 14 MeV). The neutrino energy was underestimated in the cited note. Let us obtain a more accurate expression for the energy of the neutrinos produced during the course of neutronization of helium.

The production of high-energy neutrinos upon collapse of a cold star is connected with the process

$$e^- + He^4 = T + N + \nu \qquad (1)$$

The threshold energy of this process is $Q = 22.1$ MeV $= 43.4\ mc^2$. This reaction is followed by the "easier" reaction $e^- + T = 3n + \nu$. The course of the reaction (1) is made complicated by the fact that the H^4 nucleus does not exist and that the neutronization is accompanied by emission of a neutron. Nor does the H^4 nucleus apparently exist like a virtual state [4]. It is therefore natural to assume in first approximation that the matrix element depends neither on the neutrino energy nor on the neutron energy, nor on the angle between them, and the probability of the reaction is therefore assumed proportional to the phase volume.