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THE ANISOTROPY OF THE MAGNETIC FIELD INDUCED RESISTIVE TRANSITION IN SINGLE CRYSTAL $Bi_2Sr_2Ca_ICu_2O_8$

A.A.Drozd, A.P.Ges, A.A.Ignatenko, V.Ch.Kruplevich,
L.A.Kurochkin, V.R.Sobol and D.I.Zhigunov
Institute of Physics of Solids, Academy of Sciences
of the BSSR, Minsk 220726 USSR

The dissipation observed at the superconducting transition of the high-T_c superconductor $Bi_2Sr_2Ca_ICu_2O_8$ bulk sample is explained by the Kosterlitz-Thouless theory of vortex-antivortex pair excitations within the CuO_2 planes.

Measurements of temperature dependence of the resistive transition in bulk samples of Bi-Sr-Ca-Cu-O system have been done. Samples for this study were grown from the starting compounds of Bi_2O_3, $SrCO_3$, $CaCO_3$, CuO taken in the ratio 2:2:I:2 in metal and I0-30 wt% NaCl-KCl and melted in a Al_2O_3 crucible. The samples form as parallelepiped typicaly 5·3·I2 mm^3 consisted of thin single crystal plates with a ĉ-axis normal to the plate and disoriented about three degrees. An external magnetic field H was oriented both perpendicular and parallel to the ĉ. Resistivities data were taken with a standard ac phase sensitive technique with 5 mA excitation current at 37 Hz in magnetic field up to 70 kOe. Fig.I shows the shape of the resistive transition at different orientations of the sample in the magnetic field H: a - ĉ is parallel to H; b - ĉ is perpendicular to H.

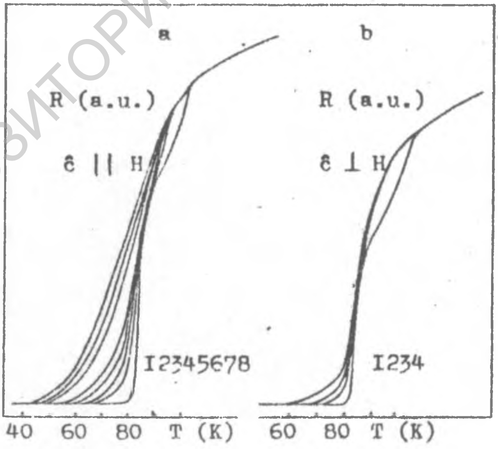
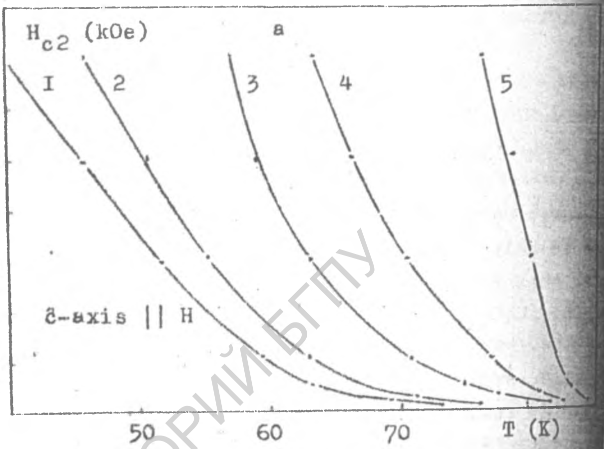


Fig.I. Resistance - temperature dependences: a - I2345678 - H = 70, 50, 30, I0, 5, 2.5, I, 0 kOe respectively; b - I234 - H = 70, 30, 5, 0 kOe respectively

The shape of the resistive transition depends strongly on the orientation of the sample and on the magnitude of the magnetic field. This deals with both the geometry of the experiment and a definite physical causes. Fig.2 shows the dependence of the upper critical magnetic field upon temperature: a - the ĉ-axis is parallel to the H, b - the ĉ-axis is perpendicular to the H. We have taken upper critical magnetic field $H_{c2} = H(R/R_N = 0.0025)$, where R_N is the appropriate normal state resistance at T = IIO K. In fact we have plotted this diagram for R/R_N = 0.0025, 0.0065, 0.059, 0.I4 and 0.4.



A characteristic structural feature of the new high-T_c superconductors is the presence of Cu-O planes suggesting strongly two-dimensional physical properties. In particular the class of oxide superconductors Bi-Sr-Ca-Cu-O was found to show large anisotropic behaviour in the normal state resistivity /I,2/, upper critical field /3,4,5/, together indicating a system of superconducting CuO_2 planes which are wearkly coupled. If the system remains strongly two-dimensional then the planes would show behaviour analogous to the thermal fluctuations in thin films of conventional superconductors where the dissipation is associated with the motion of thermally excited pairs of vortices with opposite circulation /6,7/. An isolated superconducting sheet would be

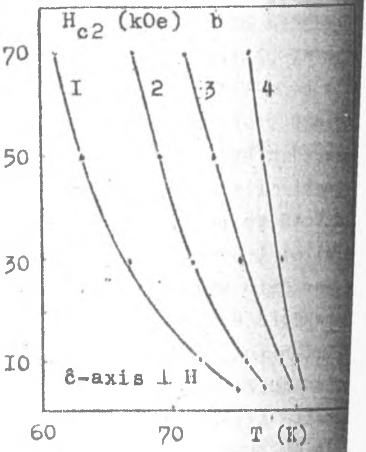


Fig.2. Temperature - uppe upper critical fie dependences, I, 2, 4, 5 - R/R_N = 0.00 0.0065, 0.059, 0.I 0.4 respectively.

described by the Kosterlitz-Thouless theory of phase transitions in two-dimensional systems /8-I0/, where the vortex pairs remain bound below the transition temperature T_c, which lies below the mean field Ginzburg-Landau transition T_{co}. The evidence for two-dimensionality in this case in particular is found in an exponential square-root singularity in temperature dependence of the resistivity near T_c. Using the data obtained for $H = 0$ (with an accuracy of uncompensated earth magnetic field $H \simeq I$ Oe) we plot the quantity $\ln(R_N/R)$ as a function of the $(T - T_c)^{-0.5}$ and find good agreement with the expected dissipation resulting from thermally activated dissociation of vortex-antivortex pairs just above T_c for $0.0025 \lesssim R/R_N \lesssim 0.4$ and $82.4\ K < T < 85.I\ K$. (see Fig.3). From the best linear fit to the data near T_c we obtained the Kosterlitz-Thouless phase transition temperature $T_c \simeq 82.2$ K coincided with the $R = 0$ point at zero magnetic field /II/. Magnetic field induced vortex depairing and flux-flow resistivity is indirectly observed in not linear dependence of the $\ln(R_N/R)$ as a function of the $(T - T_c)^{-0.5}$. The mean field transition temperature $T_{co} \simeq$ [illegible] K was obtained by fitting the data above T_{co} with the Aslamosov-Larkin [illegible] for the fluctuation conductivity in two-dimensional system and a ratio $R(T_{co})/R_N =$ [illegible], which is closed to the midpoint at 86 K /II-I3/.

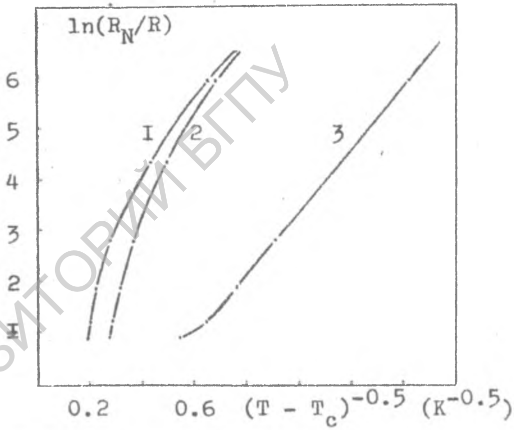


Fig.3. $\ln(R_N/R)$ vs $(T - T_c)^{-0.5}$
I, 2 and 3 - H = I0, I and 0 kOe respectively

In conclusion, measurements of the superconducting transition in [illegible]k single crystal samples reveal large anisotropy both the magnetic field induced resistance and the upper critical field involving dissipation arising from excitations of two-dimensional vortex-antivortex pairs. It is shown that the Kosterlitz-Thouless theory [illegible] applicable under the experimental conditions because the inter[illegible]ar coupling is particularly weak in Bi-Sr-Ca-Cu-O.

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