MAGNETIC PROPERTIES OF La—Sr—Cu—O SUPERCONDUCTOR AT SMALL MAGNETIC FIELDS

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An important property of ceramic oxide superconductors is the penetration into a sample of very small magnetic fields (order of 1—10 Oe). Some noninvertible phenomena such as the trapping and pinning of the magnetic flux /1/ are connected with this effect. It is supposed that these processes occur in the intergranular boundaries, which are weak Josephson junctions, but not in the grain's interior owing to the granular structure of these materials. The present work deals with intergranular flux pinning and flux distribution and its parameters.

Samples of $La_{1.85}Sr_{0.15}CuO_y$ of cylindrical and spherical forms with the same diameters of 6 mm (a density of 6.2 g/cm^3, and the resistance of 400 $\mu\Omega$ cm) were irradiated by a beam of polarized neutrons. The magnetic fields were applied to the sample parallel or perpendicular to the neutron beam. Polarization of the beam initially oriented perpendicular to the magnetic field rotated around this direction. The projections of polarization were measured with the external magnetic field switched off. Therefore the fixed changes of polarization were explained by the rotation of the polarization vector around the remaining field B_r which appeared due to a flux trapping. The angle of rotation φ was proportional to the mean field B_r and the path length L of the neutron in this field was $\varphi \sim B_r L$. The dependence of one of the components of polarization vs magnetic field (fig. 1a) reflects the typical peculiarities of the penetration and pinning of a flux.

The turn was started from some fields the values of which are dependent of the temperature. Such a field for instance, is about 8—9 Oe at a temperature of 4.8 K. The absence of the turn can be explained either by the absence of pinning or by screening of the sample by superconducting currents on the external field. However the difference between the rotation periods of polarization for the sample in the normal and the superconducting states by the same external field is the result of the change of the neutron path length δL. The value δL was constant up to the field H=8 Oe and actually coincided with the sample diameter (fig. 1b). Therefore the magnetic field doesn't penetrate the sample. At higher fields the screening is broken and the field penetrates into the intergranular boundaries and voids.

Small depolarization (fig. 1c) doesn't confirm that the vortices in the boundaries are twisted both by pinning forces and by boundaries of chaotic spatial distribution. The flux distribution is nonuniform only in the small fields region. This result follows from the values of the turning angles $\varphi_\parallel$ and $\varphi_\perp$ of polarization for two orientations of the magnetic field relatively to the direction of the neutron beam. A detailed analysis shows that the ratio $\varphi_\parallel/\varphi_\perp$ for a uniform magnetized sphere must be equal to 2. In the given experiment this ratio held for H>20 Oe if the temperature was T=4.8 K and for H>13 Oe if T=19.5 K (fig. 2a). When $\varphi_\parallel/\varphi_\perp<2$ the density of the vortices was rather small. The highest possible density of the vortices was about 10^8 cm^{-2} and their size was about 0.5—0.8 μm (fig. 2b).

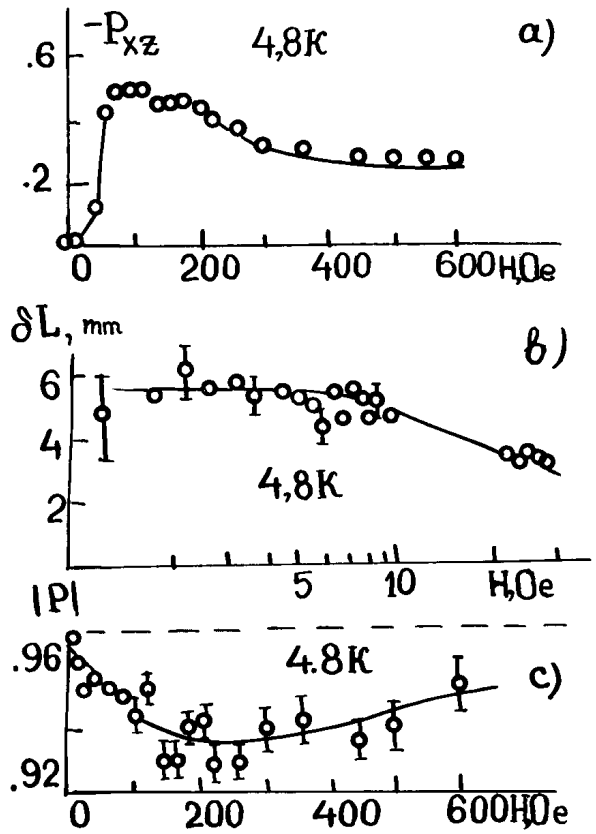

Fig. 1

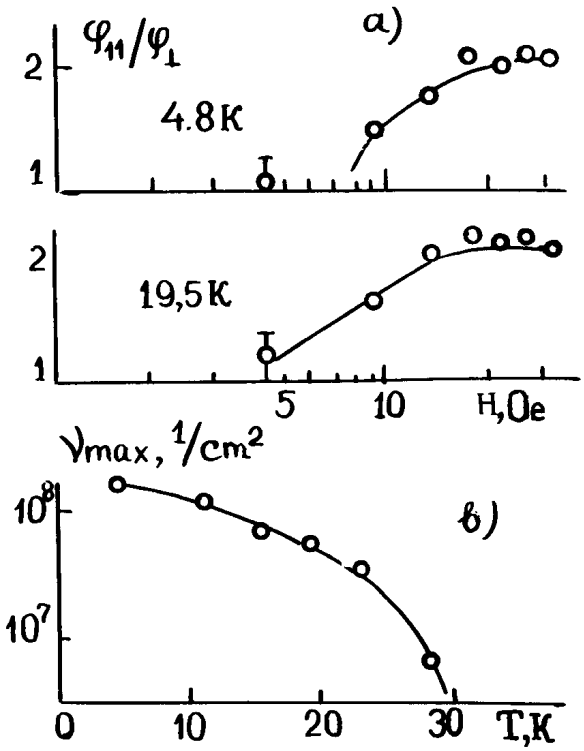

Fig. 2

The temperary relaxation of the residual magnetization obeys the logarithmic law which describes the flux creep in low temperature rigid superconductors. Within the limits of the thermal activation character of the flux creep the energy barrier U_0 was determined from the experimental values of the critical current (about 100 A cm^{-2}) and the logarithmic relaxation rate. Its dependence on temperature is not linear and at T=4.8 K the energy barrier is U_0=5 meV.

REFERENCE

1. *Akselrod L. A., Gordeyev G. P., Lazebnik I. M. et al.* Pisma v ZETPH, 1987. V. 46. P. 161. Supplement.