RESISTIVE STATE IN La-Sr-Cu-O AND Y-Ba-Cu-O

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We have investigated galvanomagnetic effects in ceramic specimens of $La_{2-x}Sr_xCuO_{4-y}$ with x = 0.10 (specimen 1), $Y_2Ba_3Cu_7O_{14-y}$ (specimens 2,4), and $Y_1Ba_2Cu_3O_{7-y}$ (specimen 3) in temperature range $4.2 \leq T \leq 300$ K in magnetic field H up to 50 kOe. The temperature dependences of resistivity ρ for all specimens are presented in fig.1. The superconductive (SC) transition temperatures T_c and the resistivity in the normal phase ρ(100 K) are given in the Table.

The dependences of resistivity on magnetic field $\rho(H)$ for La-Sr-Cu-O and Y-Ba-Cu-O at $T<T_c$ and $j<j_c$ are presented in Figs 2 and 3. It is seen that as the magnetic field is increased, the resistivity rises sharply in some H^* and then attains saturation ρ_{sat}. The value ρ_{sat} is a weak function of the magnetic field up to H = 50 kOe. With the current density j increasing in the specimen, ρ_{sat} rises (see Fig.2) but remains several times smaller then ρ(100 K) in the normal phase (see Table). The observed phenomenon is independent of the specimen orientation in magnetic field.

Hysteresis phenomena were revealed in studying $\rho(H)$. We found that the $\rho(H)$ curves do not coincide when the magnetic field is on and off (Figs 2,3). Besides, when the magnetic field is removed, resistivity does not become zero but remains a finite quantity equal to ρ_{res}, relaxing slowly with time: ρ_{res} decreases by 4% (specimen 1) and 7% (specimen 2) during 30 min. The specimens regain superconductive properties only after heating to $T > T_c$ and subsequent cooling.

In accord with the assumption made in /1,2/, inhomogeneous SC with weak inter-granule bonds can pass to the state of a superconductive glass (SCG) in some magnetic field $B > B^* \propto \Phi_0/S$, where Φ_0 is the magnetic flux quantum and S is the mean cross-section of the effective contour of superconduction current in the percolation network of granules. The SCG state must be non-ergodic, exhibiting numerous metastable energy minima separated from each other by energy barriers. Thus, the trapping of the system in metastable states results in hysteresis phenomena and leads to time dependence of resistivity, the situation which was actually observed in experiment /3,4/.

It might be expected that, similar to a usual spin glass, the nonergodicity will manifest itself in the difference of physical quantities obtained when cooling a specimen from high temperatures in a finite magnetic field or in a zero magnetic field. A slow coolong in a fixed magnetic field to $T < T_s$ (T_s is the temperature of transition to the SCG state) will bring the system to an equilibrium state since the system will have enough time for rearrangement. Cooling in a zero magnetic field with subsequent rapid application of the field at $T < T_s$ will bring the system to a metastable state. In usual spin glasses, this difference between the equilibrium and matastable states shows up, for example, in the difference between the thermoresidual magnetization (TRM) and the isothermal residual magnetization (IRM) /5/. By analogy, it may be expected that in the SCG state, where residual resistivity is observed, the thermoresidual resistivity (TRR) and the isothermal residual resistivity (IRR) will exhibit different values.

The experiment was performed on specimens 1 and 5 according to the technique described in /4/. The results obtained are given in Fig. 4. As one would expect, the TRR and the IRR exhibit a different dependence on the external magnetic field: they differ greatly in weak fields and get closer in strong fields. The behaviour of the IRR is distinct from that of the isothermal residual magnetization in usual spin glasses in that the IRR starts growing from a non-zero field.

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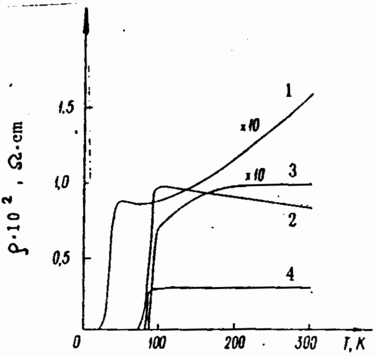

Fig.1

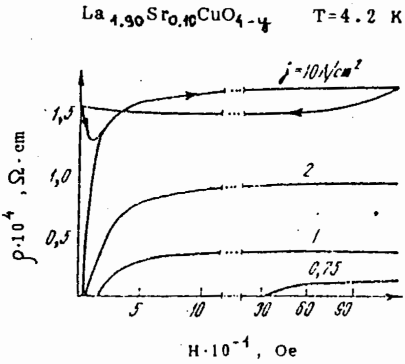

Fig.2

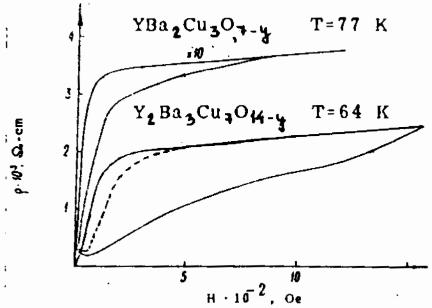

Fig.3

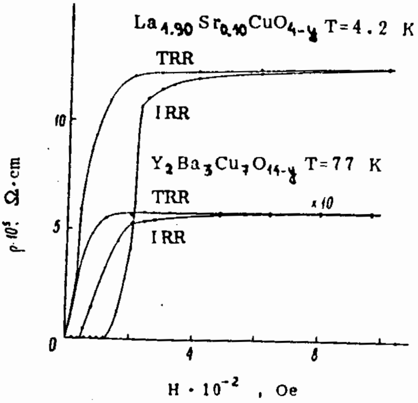

Fig.4

Table

N	Substance	T_C,K	ρ(100K),mΩ·cm	ρ_{sat},mΩ·cm
1	$La_{1.90}Sr_{0.10}CuO_{4-y}$	23	0.85	0.10
2	$Y_2Ba_3Cu_7O_{14-y}$	73	9.3	2
3	$YBa_2Cu_3O_{7-y}$	88	0.68	0.35
4	$Y_2Ba_3Cu_7O_{14-y}$	82	2.6	