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Scaling behaviour of relaxation dependences in metaloxide superconductors

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In a variety of experiments (see, e.g. Muller *et al* 1987, Havronin *et al* 1988) it was shown that the superconducting glass state is realized in granular superconductors (Josephson media) for fields $H \ll H_{cl}$ (H_{cl} is a first single-crystal critical field). These state properties are determined by the frustration of weak superconducting links. In particular, a slow logarithmic relaxation of the thermoremanent magnetization is observed

$$M(t) = M_0 - S_{\text{int}}.$$

In some cases, the dependence of the relaxation rate $S = -\,\mathrm{d}M/d_{\text{int}}$ on temperature and external magnetic field were investigated. For instance, it was discovered that for powder samples of La-Sr-Cu-O system the power-law dependence occurs: $S \sim H^3$ (Mota *et al* 1987).

In the present work we have measured the magnetization relaxation at $T = 4{\cdot}2$ K in two substantially different superconductors: $BaPb_{0{\cdot}75}Bi_{0{\cdot}25}O_3$ (BPB, $T_c \approx 10$ K, $H_{c1} \approx 12$ Oe) and $YBa_2Cu_3O_{7-x}$ (YBCO, $T_c \approx 92$ K). The SQUID magnetometer with active and passive electromagnetic field shielding guaranteed measurements for H up to 900 Oe. The polycrystalline specimens were prepared by the solid-state synthesis method.

It is difficult to determine the precise value of H_{c1} for the YBCO ceramics. But, according to literature, H_{c1} is between 300 Oe and 1500 Oe, the discrepancy being due to the strong anisotropy of the superconducting properties of metaloxides YBCO (Shelton 1987).

Dependences of S and the trapped magnetic flux M_0 under the field-cooled (FC) condition on the magnitude of the external magnetic field $H(5 + 600\,\text{Oe})$ were determined. In BPB samples for fields $H \gtrsim H_{c1}$ the curves $S(H)$ and $M_0(H)$ started to saturate, whereas in YBCO ceramics the saturation of $S(H)$ and $M_0(H)$ was not achieved for accessible fields.

At first sight the experimental data differ greatly. But the results can be represented as the dependences of S on M_0. Then, as can be readily seen from figure 1, the experimental data for various samples follow the universal scaling dependence $\ln S = k \ln M_0$ with the exponent $K \approx 3$. This agrees with the results of Mota *et al* (1987), if one suggests that M_0 is proportional to H in Mota *et al* (1987), where the isothermal conditions have been used.

The observed universal dependence $S \sim M_0^3$ is probably a manifestation of the

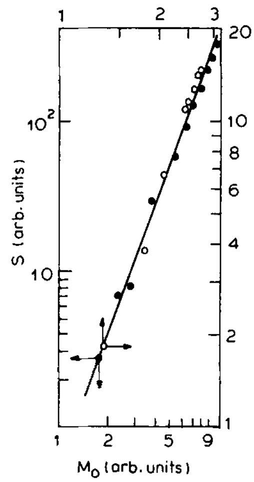

Figure 1. Scaling law for relaxation rate $S = dM/d_{int}$ (● YBCO, ○ BPB).

superconducting glass state in porous ceramics. It is interesting to note that the observed behaviour does not depend on the type of weak links between superconducting grains (S-I-S links in BPB or S-N-S links in YBCO) and critical current magnitudes which are quite different for the samples studied.

Scaling law for relaxation rate $S = -dM/d_{int}$

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