# INVESTIGATION OF SUPERCONDUCTIVITY AND MAGNETISM IN CERAMIC $YBa_2Cu_3O_{6+x}$ SAMPLE

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This work presents the results of μSR-study of 1.2.3.-compound ceramic samples with different oxygen contents $0.10 \leqslant x \leqslant 0.95$ at $4.7K \leqslant T \leqslant 370K$. As follows from the analysis of the temperature dependences of the integral positron counting rate $n_e$ /1/ (fig. 1) and from the muon spin depolarization function G(t), these samples can be put into three groups.

For the samples with $0.55 \leqslant x \leqslant 0.95$ no internal magnetic correlations have been observed because the value $n_e$ at $H=0$ was constant and close to its maximum quantity $n_e^{max}$ at temperatures (4.7—150)K and $G(t)=\exp(-\sigma^2 t^2)$ had a relaxation rate $\sigma=(0.11—0.12)\cdot 10^{-6}$ S due to a dipole

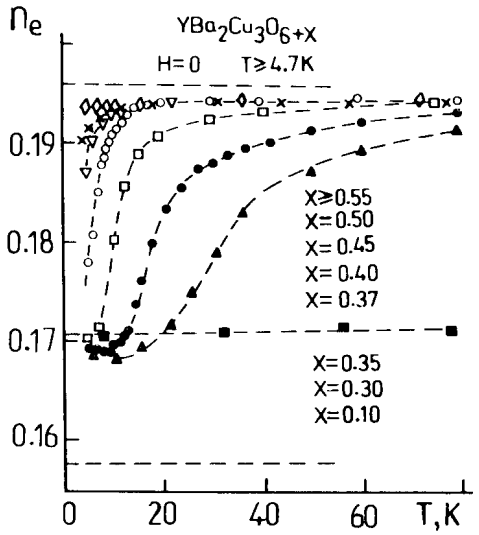


Fig. 1. Dependence of integral positron counting rate $n_e$ on temperature for samples with different oxygen contents. Dashed lines correspond to:
upper — $n_e^{max}$ (T=290K, H=0),
lower — $n_e^{min}$ (T=290K, H=34mT),
middle — $n_e^{min}+1/3(n_e^{max}-n_e^{min})$

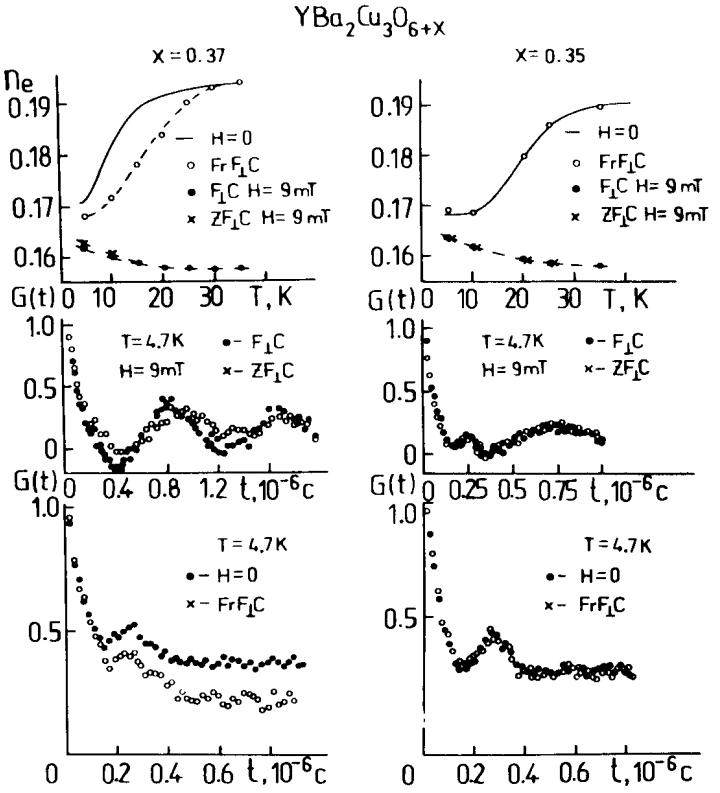


Fig. 2. Dependence of measurement result on cooling methods. For explanation to FC, ZFC, FrFC see text

interaction with copper nuclear magnetic moments. Superconducting transitions took place in these samples at $55 \leqslant T_c \leqslant 90$K and their widths were $\Delta T_c = (1-2)$ K and $\Delta T_c = (6-10)$ K at $T_c = 90$K and $T_c \approx 60$K. It was shown also that the magnetic properties of these superconductors in external magnetic fields are very close to the properties of the conventional type II superconductors with the exception of the features related to superconducting anisotropy and granular (ceramic) structure /2—4/. It was found that measured experimental parameters (such as the magnetic flux exclusion, the magnetic field dispersion in mixed state, etc.) significantly depended on a macrostructure formed by technological conditions (such as the initial crystallite size, conditions of heat treatment). The deflection of the vortex magnetic flux directions from the external magnetic field direction assosiated with superconducting anisotropy have been observed by measurements on small external magnetic fields.

In the samples with $x \leqslant 0.35$ the superconducting phase was not observed but the transitions to a magnetic state took place at $T_N > 22$K. As is seen from fig. 1 in these samples $n_e$ decreases to quantity $n_e^{min}+1/3(n_e^{max}-n_e^{min})$ only because at $T < T_N$ the internal magnetic fields are quasistatic and isotropic. The same conclusion follows from study of the muon depolarization function G(t). Internal magnetic fields occupy not less then 95% of the total volume in these samples as well as in the sample with x=0.37 at T=4.7K.

The function G(t) for the magnetic state consists of two components. The first one including about (35—45) % of the muons corresponds to a collinear magnet with a Gaussian magnetic field distribution and with a mean value of the magnetic field larger then its dispersion. The second component conforms to the muon depolarization function in magnetic fields with a Lorentzian distribution when the dispersion is much larger than the mean value of the magnetic field. But this is not a spinglasslike state because it is reversible /3,5/.

In the samples with $0.37 \leqslant x \leqslant 0.50$ the magnetic transitions at $T_N < 15$K as well as the superconducting transitions with $T_c > 30$K have been observed. The widths of the superconducting transitions were about (15—20) K. However, part of the superconducting phase at T=15K for $x \geqslant 0.40$ was not less than 90% of the total sample volume and for x=0.37 — not less than 40% at the same temperature. The determination of the superconducting phase volume at lower temperatures by the μSR-method is difficult because of the large dispersion of the internal magnetic fields.

All the samples with $0.37 \leqslant x \leqslant 0.95$ in contrast to the samples with $x \leqslant 0.35$ demonstrate the irreversibility. As is seen from fig. 2 and references 2 and 3 the results of measurements at certain temperatures and external magnetic fields depend on whether it is cooled with the external field (FC) or without it (ZFC). And, finally, some magnetic flux is trapped after the external magnetic field is switched off (FrFC).

The susceptibility measurements done in the 0.025mT a. c. magnetic field for sample with $x=0.37$ showed that the relative superconducting phase volume at $T=4.6K$ is not less than 70%. Therefore superconductivity and quasistatic magnetic ordering it seems coexist on the macrescopic level.

REFERENCES


1. *Barsov S. G. et al.* Preprint LNPI-1312. Leningrad. 1987. 20 p.
2. *Barsov S. G. et al.* Superconductivity physics, chemistry, technics. 1989. V. 2. N 5. P. 42—50.
3. *Barsov S. G. et al.* Preprint LNPI-1529. Leningrad. 1989. 14 p.
4. *Barsov S. G. et al.* Preprint LNPI-1531. Leningrad. 1989d. 16 p.
5. *Barsov S. G. et al.* Preprint LNPI-1552. Leningrad. 1989. 10 p.