STUDY OF MIXED STATE OF $YBa_2Cu_3O_{6.9}$ SUPERCONDUCTING CERAMICS BY METHOD OF THERMAL NEUTRON DEPOLARIZATION

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A study of the structure of the magnetic flux in high-temperature superconductors (HTSC) is necessary to understand the pinning processes and the possibility of increasing critical currents in these materials. In the study /1/ we have demonstrated the promise offered by the method of neutron depolarization for investigating the mixed state of the $YBa_2Cu_3O_{6.9}$ superconducting ceramics. The given study is concerned with the dependence of neutron depolarization on the magnetic field, temperature and magnetic prehistory of the sample.

Experimental results

Fig. 1 shows the dependence of the P/P_0 ratio on the applied magnetic field at T=4.2 K. Fig. 2 presents the corresponding magnetization curve. Upon cooling in a zero field the latter increased to $+H_m$ and decreased to zero — curve 1 in fig. 1. The separated increase and decrease of the field — curve 2. The field further reversed to $-H_m$. Curve 3 corresponds to the subsequent increase and decrease of the field in the positive direction.

Fig. 2 shows (curve 1) that the magnetization and its hysteresis weakly depend on the field at $H \geqslant 6$ kOe. This means that the magnetization of granules can be considered in terms of Bean's model /3/.

Fig. 3 shows the distribution of local induction in the given model. Figs. 3 a—c correspond to the increase of the field upon 1—3 passes, fig. 1a and fig. 2, and fig. 3d to the decrease of the field from $H_m > H^+$ (determination of H^+ — fig. 2). It will be noted that the distribution at $H=H_m$ is the same in all cases. Let us further consider the behaviour of polarization P/P_0. Upon the first field's increase the value P/P_0 dramatically decreases close to $H_{cl}=800$ Oe (determined from the linear part of the magnetization curve — fig. 2) which corresponds to the onset of flux penetration into granules of the sample. The P/P_0 decrease is over when the magnetic flux front reaches the granule's centre, i. e. at H=6 kOe where the magnetization starts saturating. Thus, minimum polarization is closely re-

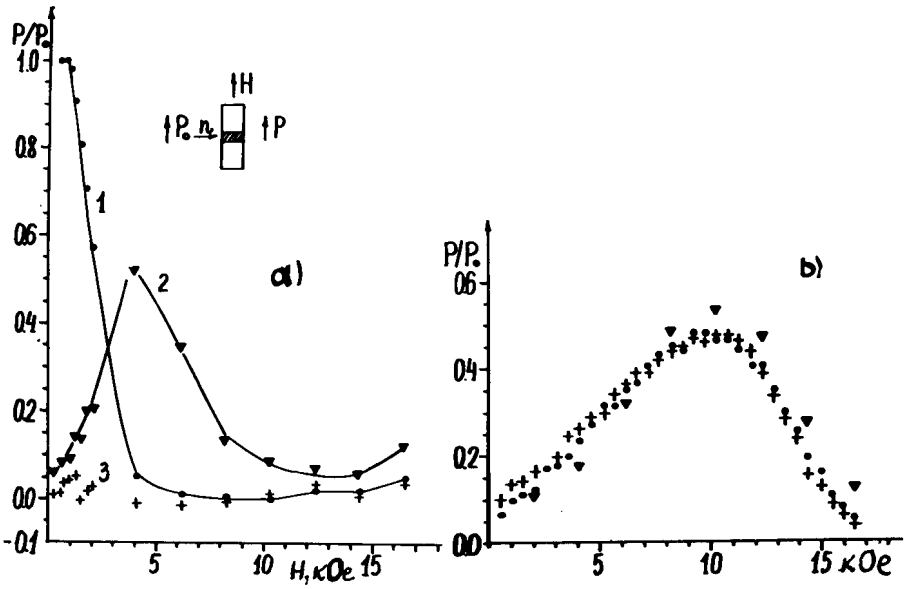

Fig. 1. Dependence of P/P_0 for ceramics on applied magnetic field, T=4.2K: *a*) increased field, *b*) decreased field

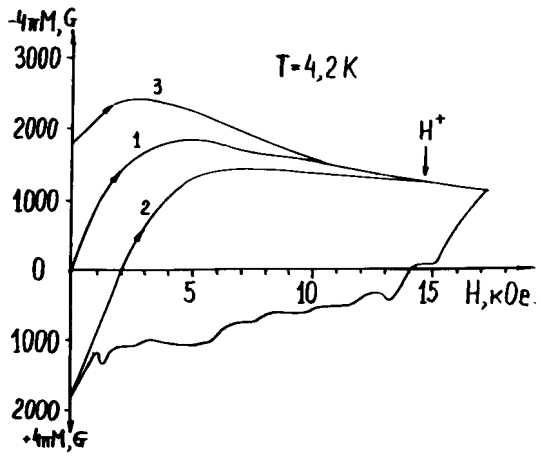

Fig. 2. Dependence of magnetization of ceramics on magnetic field, T=4.2K

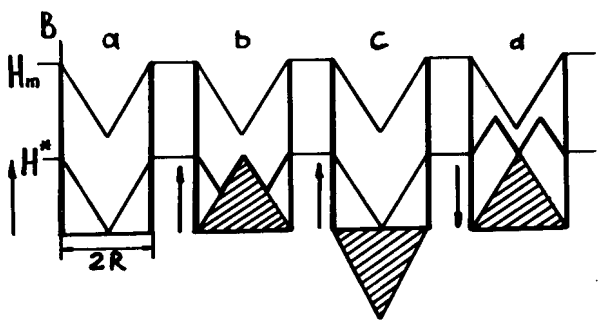

Fig. 3. Distribution of local induction in Bean's model: flux at H=0 is shaded, 2R is granule size

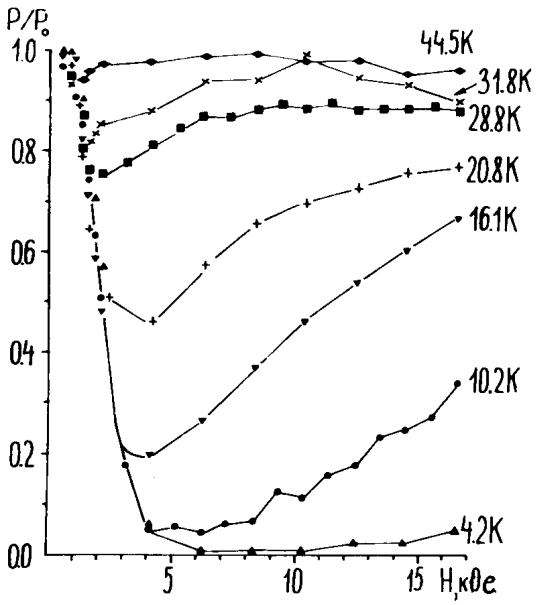

Fig. 4. Field dependences of polarization at different temperatures (increased field)

lated to occurence the critical state set into the whole granule. The further field increase up to H_m does not influence the flux profile in the granule (fig. 3a) and, consequently, in P/P_0.

According to fig. 3, the flux distribution nonuniformity in the granule is defined by the rms local magnetization over the granule's volume, i. e. $((B(r)-H)^2=(4\pi)\times(M^2)$, while on the field decrease from H_m there is a minimum on the (M^2)-curve on the field H_m-H^* and we suppose the same behaviour for $(B_\perp^2)=(4\pi)\times(M_\perp^2)$ connected with the vortex line which bends because of the pinning forces. Therefore, there must be a polarization maximum at $H_m-H^*=10.5$ kOe, which is in a good agreement with fig. 1b. Further, when the flux is trapped and the field increases (fig 1a, curve 2) the (M^2) value gets the minimum at H^*, according to fig. 3b, and polarization has its maximum at $H=H^*$. Note that the magnetization equals zero at two points where the polarization differs from the unit value (fig. 2). This means that depolarization is not defined by the sample's magnetization mean value. This corresponds to decrease of angle between vortex lines and applied field with raising both temperature and field.

REFERENCE

1. *Volkov M. P., Dmitriev R. P., Zhuchenko N. K., Trunov V. A., Yagood R. Z.* In: Proc. of the First Sov. Conf. on High T_c Superconductors. Kharkov. 1988. V. 2. P. 68.