DISTRIBUTION OF TRAPPED FLUX IN JOSEPHSON MEDIUM

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According to classical standart models of the critical state for hard type-II superconductors [1,2] the dependence of critical current density J_c *vs* a magnetic field H is a single-valued one. In the some papers on high T_c superconductors (HTSC) [3—5] it has been pointed out that J_c is a many-valued function of external field H. The reasons are a granularity of HTSC and the flux pinning in the grain under the fields more than H_{c1gr}. In this connection an interest arose to a dependence of J_c as afunction of internal field B in the low-field electrodynamic region, when one exactly knows that field H does not penetrate into a grain, i.e. $H < H_{c1gr}$. Direct way to solve this problem is the immediate study of magnetic flux distribution within HTSC.

The distribution of quasilocal internal fields was measured by polarized neutons beam scaning the

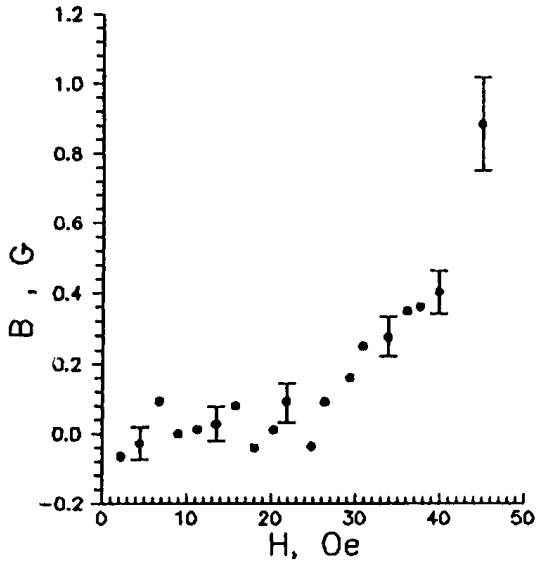

Fig.1

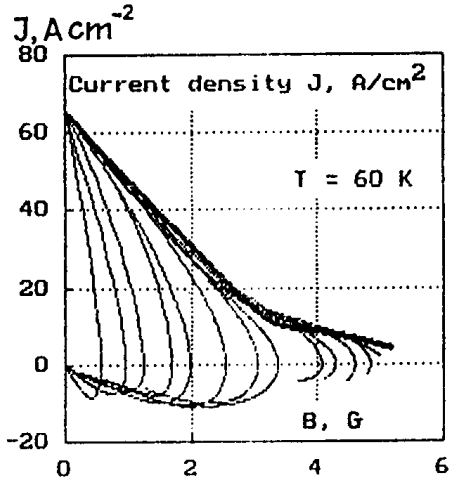

Fig.3.

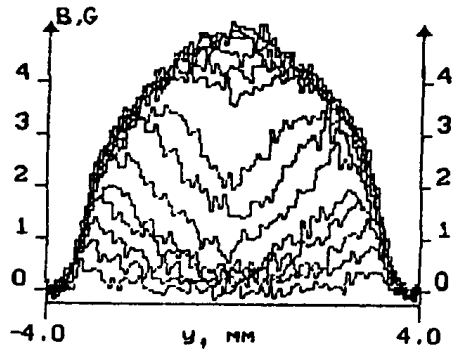

Fig.2.

sample. By the preliminary scan the powder of same Y—Ba—Cu—O ceramics showed that a flux trapping occured under the fields more than some value (fig.1). This value is determined by temperature. The flux distribution is homogeneous in the powder sample. For this reason one may conclude that the given system is not Josephson medium. The whole pinning occures only within grains, having the lower critical field $H_{c1gr} \approx 20\ Oe$ at $T = 78\ K$ and $H_{c1gr} \approx 45\ Oe$ at $T = 60\ K$.

Distribution of trapped flux within ceramic sample at $H < H_{c1gr}$ is essentially imhomogeneous (fig.2). In the centre of the sample and close to surface it is characterized by different gradients of the field B, which are

dependent on the field H. Within the sample the sign change of the second derivative of $B(y)$ is observed. The special features of distribution $B(y)$ have been reflected on current density dependence $J = \frac{dB}{dx}$ versus the field B (fig.3): there are two branches with essentially different values of currents at given B. Affer field $H = H_0 \approx 16\ Oe$ for $T = 60\ K$ the form of distribution $B(y)$ does not depend any more on the field H, but at $B = B_0 \approx 3\ G$ (T= = 60 K) the kink appeares and practically disappeares many-valued behaviour of current density $J(B)$ (fig.3). The branch of dependence $J(B)$ corresponding to a maximum values of current, probably, presents a dependence $J_c(B)$. Many-valued dependence in our opinion indicated the absence of the critical state. This means that after the field switching off the critical state is organized under $B < B_0$ only within the regions not far from surface. Really, these regions are the ones where Josephson vortices push out each other because of their large concentration. Within the sample they interact weakly owing to their small concentration. The value of the pinning force is not maximal, therefore the trapped flux distribution does not change. Actually internal field $B = b + f_n \cdot H$, where b is the field of trapped flux, f_n is a parth of normal phase (voids). It seems, that $B(y)$ is determined by the dependence of $b(y)$ provided a normal phase (voids) was uniformly distributed. After field switching off $b(y)$ is changed near surface owing to going away surface of the Josephson vortices. Within internal region of the sample the distribution character remains the same as with the field since the pinning force decreases (a magnitization memory). When the flux density within the sample will achieve such a concentration, force that interaction force between them will be comparable to the pinning force, exit of vortices from the sample interior is possible. Now critical state will realise within the whole volume of the sample, occuring as we have already mentioned at $B > B_0$. On a dependence $J(B)$ the point $B = B_0$ corresponds to the kink, after which the current density practically does not depend on the field when B increases, accepting very small magnitudes. Probally here the Bean model [2] is suitable.

Therefore under magnetization of the sample the surface layers initially develop to critical state and then pass already the whole sample to one.

References

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