Magnetic Field Penetration into Granular Superconductors

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Multiple josephson medium is now the established model of high-temperature supercinductors (HTSC). Josephson medium is generated by a lot of small superconductive grains with weak links (josephson junctions) between them. This model permits to make a qualitative descriptions of some processes in HTSC. Thus, in paper [1] magnetic field penetration into granular superconductor is described which occurs in the form of magnetic vortices. Such vortices are called "supervortices" in [1]. Neither analytic nor numerical study of "hypervortices" are not realized at present time.

In present paper the multiple josephson medium is averaged on the volume containing a lot of grains and, at the same time, large enough to consider magnetic field to be permanent in it. Averaging provides to material equation coupling the current density $\vec{j}$ with magnetic field vector potential $\vec{A}$:

$$\vec{j} = -\frac{\vec{A}}{A}\alpha M(A) - \beta\dot{\vec{A}} - \gamma\ddot{\vec{A}}$$

where α, β and γ are some coefficients depending on medium macroscopic parameters. Dependence $M(A)$ determines by the size-distribution low of the grains and looks approach identical for different media.

Stationary solutions with radial symmetry of equation obtained are analyzed. Magnetic flux containing in such solutions is shown by numerical modeling to be divisible by $2\Phi_0$, where Φ_0–magnetic flux quanta.

Whole energy of the medium described is investigated as the sum of magnetic field energy and the josephson junction energy. Calculation of the solution obtained whole energy permits to plot the graph of its dependence on amount of magnetic flux quanta containing in these solutions. These graphs are monotone for each size-distribution low considered and this fact allows to conclude that solutions are the most energetically benefit containing two magnetic flux quanta.

Thus, magnetic field penetration into multiple josephson medium must take place in the form of vortices as it was shown in [1]. In contrast to type II superconductors and distributed josephson junctions, however, vortices described must contain two quanta of magnetic flux. This result is unexpected, nevertheless, it was point to possibility of multiquantum magnetic formations sooner in [2], and this appearance took place also in complicated josephson structures.

REFERENCES

1. Sonin, E. B., *JETP Letters*, Vol. 47, No. 8, 415, 1988.
2. Belodedov, M. V., *PHYEM'05 Proc.*, 297.