Session 3P8a
Microwave Related Phenomena in Superconductors

Experimental Studies on the Macroscopic Anisotropy of High Temperature Superconductor YBaCuO

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To investigate the anisotropy of magnetization critical current density of high temperature superconductor (HTS) YBCO, two kinds of experiments were designed. First the current distributions were obtained from the trapped fields of a cubic bulk (#1) with $10.0 \times 10.0 \times 10.0\,\mathrm{mm}^3$ in size at 77 K. Nextly two small samples were employed using vibration sample magnetometer system. Their size are $4.9 \times 1.1 \times 0.4\,\mathrm{mm}^3$ (#2) and $1.0 \times 3.9 \times 0.8\,\mathrm{mm}^3$ (#3) along the a, b and c axis respectively. It was found that the anisotropy ratios of critical current density in both cases are about 3.5 independent of the applied field at 77 K. While the field is kept constant at 1.0 T, the ratio increases as the temperature decreasing from 85 K to 20 K. Moreover, when the anisotropy ratio into account in the HTS computation modeling, the calculated levitation forces between superconductor and magnet agree with the experimental ones.

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Interaction between Abrikosov and Josephson Vortices Induced by Microwave Magnetic Field and External Magnetic Field in Bi2212 Crystal: Vortex Dynamics under Crossing Field

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Reentrant phase (RP) was proposed by Fisher and Nelson for strong two dimensional high Tc superconductors. Due to less interaction between 2D pancake vortices at low fields, there is Liquid-RP just above Meissner phase under Solid mixed phase. It is very difficult to detect this RP experimentally because it is quite narrow. The vortex phase is concerning to mobility of vortex, then we tried to detect this RP employing modulated microwave absorption (MA) technique utilizing induced vortex dynamics due to high-frequency modulation field. The MA vs field (H) spectrum for H//c shows only a sharp first peak: P1 arising from Meissner state at low field at well low temperatures (T). At some higher T, it shows a Dip just above P1 and following Broad peak: Pb. The Dip and Pb arise from the Liquid-RP and Solid phase, respectively. At much higher T, the Dip and Pb disappear because it approaches to critical temperature. From these results of MA vs T, we can obtain RP experimentally. It exhibits a narrow entrance of RP which is strictly similar to the theoretically proposed RP.

Microewave power (Pm) dependence of MA was obtained for H//c at low T. The Dip and Pb appear at higher Pm and they shift to low field with increasing Pm. Their sharp drops in rather low Pm region are explained by sample temperature rise. However, their gradual drops in much higher Pm region is interpreted by vortex interaction between Abrikosov Votex induced by the applied field (AVa) and Josephson Vortex induced by microwave magnetic field (JVw). AVa is pinned by JVw at the higher Pm then the upper Solid phase boundary extends to higher field.

MA spectra were measured for Crossing field configuration (H//45ì). With increasing Pm, the Dip is extremely enhanced and Pb is shifted to higher fields. JVw decouples 2D pancake vortices then melting is promoted at the low field. While at the higher fields, AVa is pinned by the applied field-induced Josephson vortices (JVa) and JVw, then the upper Solid-Liquid boundary is shifted up.

Calculation of the Field Distributions of Superconducting Strips by Conformal Mapping

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We present magnetic-field and current distributions in superconducting strips calculated by using the conformal mapping technique. The thickness of the superconducting strips (i.e., tapes or films) is much smaller than the width, and the strips are infinitely long along the z axis. The field distributions in the xy plane are described by the complex fields $\mathcal{H}(\zeta) = H_y(x, y) + iH_x(x, y)$ that are analytic functions of $\zeta = x + iy$, and the expressions of $\mathcal{H}(\zeta)$ are derived from the conformal mapping.

We consider superconducting strips exposed to a uniform applied magnetic field H_0 and/or a transport current I_0, where H_0 and I_0 are fixed after slow increase from zero. When superconducting strips are exposed to H_0 that is smaller than the penetration field H_s, the strips are in the ideal Meissner state and the magnetic flux does not penetrate into the stirps. For $H_0 > H_s$, on the other hand, the magnetic flux penetrates into the strips: the magnetic flux stays near the center of the ideal superconducting strips without bulk pinning, or the magnetic flux penetrates only near the superconducting strips with bulk pinning. We show field distributions for various arrangements of multiple superconducting strips; i.e., coplanar strips, stacked strips, radially arranged strips, etc.

Electromagnetism of the Rings of Saturn: The Role of Levitation Force and "Negative Pressure" for the Superconducting Origin of the Thin Radially Streched Structure of the Edges of Gaps and Braid Structure of the *F* Ring

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Presented in the paper model is a direct continuation of the paper by J. K. Maxwell (1859), he deduced that rings consist of particles. Unfortunitely, for his time the was no knowledge about superconductivity (1911) and force of magnetic levitation (1933). Superconductivity of ice and high temperature superconductivity was discovered just in 1986. Importance of the force of magnetic levitation and magnetic "negative pressure" was introduced into space physics for the first time in [1–3] for explanation and mathematical approval of origin of the rings, and organic molecules propagation in between stars. In the disc of rings paricles will be located on such a Kepler orbit, where there is a balance of the three acting forces: gravitational, centrifugal and force of levitation. On another hand, paricles will be holding on the duistance from the planet by the "negative pressure", which is created by the force of magnetic levitation, and directed from the planet, backward to the force of gravity. At the end of its movement within protoplanetary cloud particles will be allocated within Roche zone. It is also following that the plane of the rings is localizing within magnetic equator of the Saturn which is not exactly coincides with its geographical equator. So, it is necessary to measure this small angle gap by the space probe. The movements of the particles driving by centrifugal force within the rings around the planet will be affected by gravitational and levitation forces. Force of levitation is proportional to the gradient of the magnetic field of the planet. The gradient is stronger on the distance closer to the planet. Radial displacements of the particles within the rings, dependce of the balance of gravitational force and force of levitation force. As a result of action of the three forces particles are participating in a helical movements within the rings. Period of the helic is becoming to be bigger with arising distance from the planet. Particles even could move out of the ring, but then the pressure from the bigger magnetic flow in between the rings will push them back to the ring. These displacements is difficult to regester within the structure of the ringlets by the space probe, but obviously dispacements are well observed at the edges of the gaps, how it is happened with the help of Cassini-Huygens observation of the thin radially stretched structure of the edges for the Encke and Keeler gaps. It is clear that the magnitude of displacements will be bigger on inner edges of the gaps. Far from the planet, near by the ring F, levitation force becomes to have less influence, and period of helical movemetns is very much extended. As a result, obsever see it like a braid or strand structures. On the distance from the planet, bihind the ring F, influence of the force of levitation becomes to be negligible, and there is no formation of the rings structure. Certainly, presented picture will be affected by perturbations produced by a satellites on a circular orbits, by fluctuations of the magnetic field of the planet, by plasma phenomena and collisions of the particles, etc.

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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.

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