

AC susceptibility with superimposed DC magnetic field in a current biased granular High Tc superconductor

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We have investigated the effect in AC magnetic susceptibility, $\chi_{ac} = \chi' + j\chi''$, of both DC transport current, J_t , and DC magnetic field, H_{dc} , in polycrystalline HTSC. Two regimes are observed: at low DC fields critical state is modified by the current self field; but as H_{dc} is increased, J_t becomes dissipative ($V_{dc} \neq 0$) and χ_{ac} is determined by the sample's "resistance".

1. Introduction

We have studied the effect in $\chi_{ac}(H_{dc})$ of a superimposed DC current, which accounts for the mutual influence of transport, J_t , and inductive, J_s , currents. Calculations were performed for a thin slab of thickness $2d$ assumed in critical state (CS), with local field dependent intergranular critical current [1], $J_c(H(x)) = \frac{\alpha(T)}{\mu_{eff}(T)} \frac{1}{(H(x)+H_0)}$, where $\alpha(T)$ is the density of intergranular pinning forces, H_0 a constant that limits the critical current at zero field and μ_{eff} is the effective permeability due to diamagnetism of grains [2]. The transport current self field, H_s , was assumed parallel to the DC and AC applied fields, H_{dc} and H_{ac} .

Fig.1 shows calculated screening capability, χ' , and AC losses, χ'' , as function of H_{dc} , for different J_t , arrows indicating when the asymmetric AC field profiles fully penetrate the sample. The system is driven out of CS when the boundary conditions at $\pm d$ can no longer be satisfied, and χ' saturates to μ_{eff}^{-1} while χ'' becomes zero.

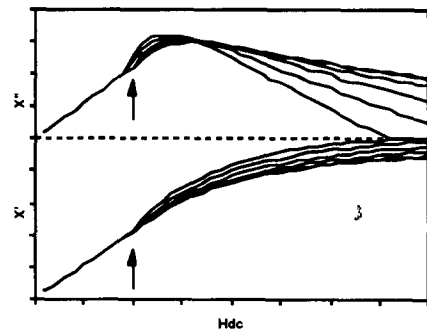


Figure 1. Calculated χ' and χ'' as a function of H_{dc} for different J_t .

2. Experimental

With a conventional experimental set up [3], we have measured χ_{ac} of granular pure (S1) and chlorinated (S2) LSCO samples, prepared as described elsewhere [4]. Results were similar for both samples.

Once the sample was cooled to $10 \text{ K} \pm 0.05 \text{ K}$ at zero field, a constant DC current, parallel to H_{dc} and H_{ac} was passed through the longest axis of the sample with negligible self heating. As H_{dc} was increased, χ_{ac} and DC voltage, V_{dc} , were measured simultaneously, the latter with overall

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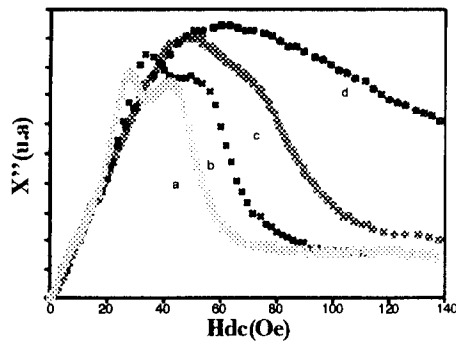


Figure 2. Measured χ'' as a function of H_{dc} , decreasing J_t from (a) to (d).

DC voltage noise of $30\eta V$. Applied $H_{ac} = 7$ mOe ($\nu = 8$ KHz) was comparable to H_s , while estimated J_s at the χ'' peak was ten times smaller than average J_t , of the order of $1 A/cm^2$.

Fig. 2. shows experimental results where χ'' displays a clear structure induced by J_t . At low fields, calculated and measured results show similar features, but the presence of the second peak is not predicted by CS calculations.

Figure 3 shows χ'' and V_{dc} as function of H_{dc} for

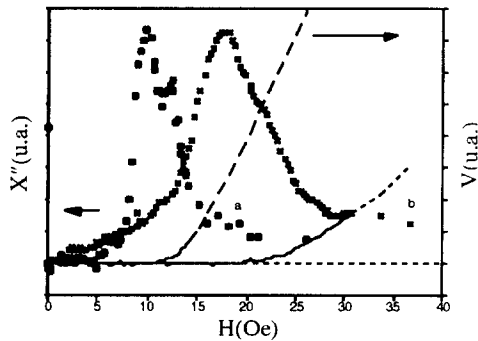


Figure 3. χ'' and V_{dc} as a function of H_{dc} , for (a) $J_t = 18mA$ and (b) $J_t = 8mA$.

different J_t , where the structure in χ'' is correlated with the onset of DC dissipation. Fig. 4 shows χ'' vs V_{dc}/J_t , indicating that the second

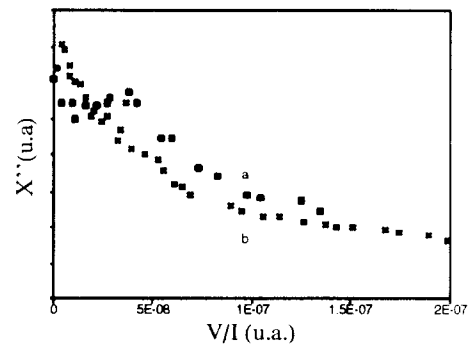


Figure 4. χ'' vs V_{dc}/J_t for (a) $J_t = 18mA$ and (b) $J_t = 8mA$.

regime is dominated by a skin depth, although DC response is not ohmic. For the experimental parameters chosen and present resolution, the influence of J_s on $V_{dc}(H_{dc})$ for a fixed J_t was negligible.

3. Conclusions

The critical state AC response as function of DC applied field with superimposed DC current ($V_{dc} = 0$, for low magnetic fields), resulted surprisingly similar to calculations, where H_s fixed asymmetric boundary conditions not reproduced in experiments. When driven out of CS by the action of current ($V_{dc} \neq 0$), to a non ohmic dissipative intergranular state, χ_{ac} seems fixed by the sample's "resistivity". Both regimes are not totally independent as is shown by the superposition of both peaks.

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