Smectic Vortex Phase at High Fields in Optimally Doped High-Temperature Superconductor

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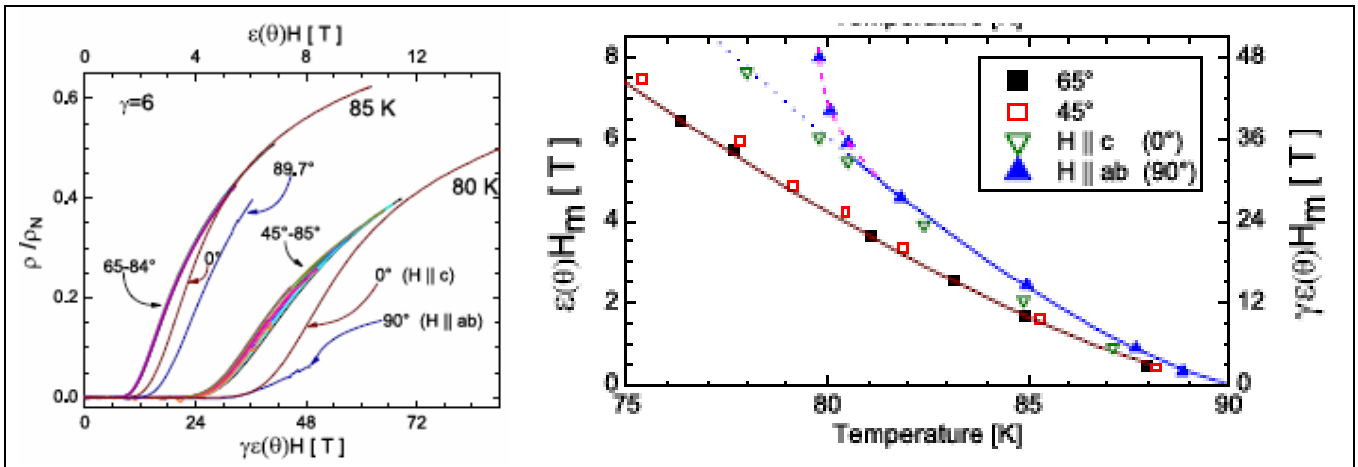
Introduction

Deep into the superconducting state when a magnetic field is applied it penetrates creating vortices, that can exist in solid, liquid, phases. The nature of these phases is given by the nature of pinning center present. [1] Also, pinning centers enable films to carry more current is an extremely important for applications of superconductivity. The most interesting case occurs along the copper oxide planes of HTS where all kinds of pinning centers are present.[2] When the magnetic field, or temperature increases the vortex lattice crosses the melting line and becomes a liquid with the concomitant increase of the electrical resistance

Experimental

Electrical ac-transport was used to measure the vortex dissipation in the liquid phase as well as to determine the melting line (where dissipation goes to zero), as a function of angle for $YBa_2Cu_3O_7$ (YBCO) films in the 50 T short-pulse magnet using the newly rebuilt rotator probe. The effect of naturally grown defects on the melting line was studied, in particular for the defects along the ab-planes.



Left: Normalized resistance vs. scaled field at two temperatures. Right: ε(θ)H vs. Temperature with the magnetic field applied at different orientations.

Results and Discussion

We find that near 80 K (H>40T), when the magnetic field is aligned with the layers, the melting line has an upward turn and the critical exponent that describes the rise in resistivity upon entering the liquid state becomes similar to that of the liquid crystal transition predicted for layered superconductors. Also we observe that up to the highest field measured (50T) correlated defects arrest the motion of vortices well into the liquid phase.

Conclusion

A long-standing debate about the existence of a smectic vortex phase in “low anisotropy” high-temperature superconductor been settled, with the evidence for smectic vortex phase in optimally doped YBCO at fields higher than 40T, available with pulsed field.[3]

Acknowledgements

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References

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[2] L. Balents and D. R. Nelson, Phys. Rev. Lett. **73**, 2618 (1994).
[3] S.A. Baily *et al.*, Physical Review Letters (Accepted for publication).