Characterization of the magnetic flux propagation in a drilled YBCO single-crystal during a pulsed-field excitation

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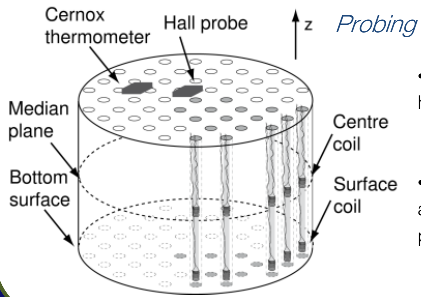
Introduction

The magnetic flux propagation inside a high-temperature superconductor subjected to a pulsed magnetic field is an important issue which determines the maximum amount of flux that is trapped after the activation. In previous studies related to that issue, several Hall probes (max. 6) were glued on the sample surface in order to characterize the flux propagation in a limited portion of the sample surface. The recent manufacturing of YBCO single crystal incorporating a lattice of artificial holes enables a deeper analysis of the flux propagation during a pulsed excitation to be carried. We use the holes in a drilled YBCO single crystal to probe locally the magnetic flux density in the bulk of the sample during a pulsed-field magnetization.

Experimental details

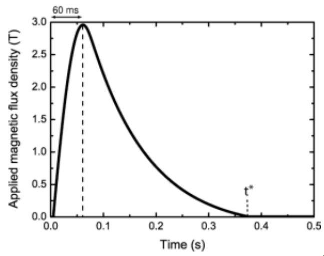


Probing the magnetic field inside the holes

- microcoils were inserted in the 16 gray holes (diameter 0.7 mm)
  - *center coil for the field in the median plane*
  - *surface coil for the field on the surface*
- coil signal amplified (10 000x) and acquired simultaneously during a single pulse

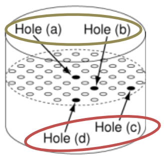
Pulsed-field activation

- use of the LNCMI facilities at Toulouse site
- pulses with amplitudes of 3T applied to the sample
- duration : +- 400 ms
- max field after 60 ms
- ZFC @ 77K before activation

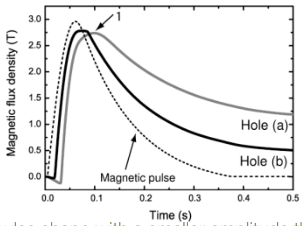


Time evolution of the magnetic field inside the holes

Median plane

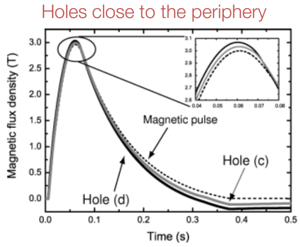


Holes close to the center



- pulse shape with a smaller amplitude than the applied pulse
- B is saturated at pulse max in hole (b)
  - *Expected from qualitative analysis based on the Bean model*
- time-shift of the max of pulse in hole (a)
- negative B at the beginning of the pulse
  - *Demagnetizing effects*

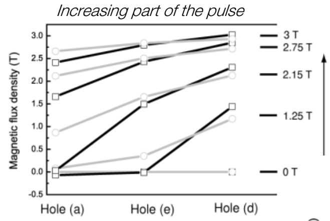
Holes close to the periphery

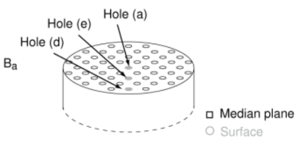


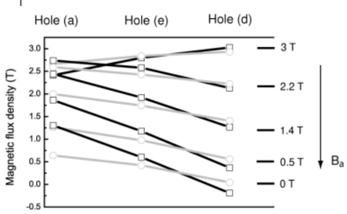
- pulse shape with a slightly larger amplitude than the applied pulse
- negative trapped magnetic flux at end of the pulse *Demagnetizing effects*

Comparison median plane - surface

Increasing part of the pulse



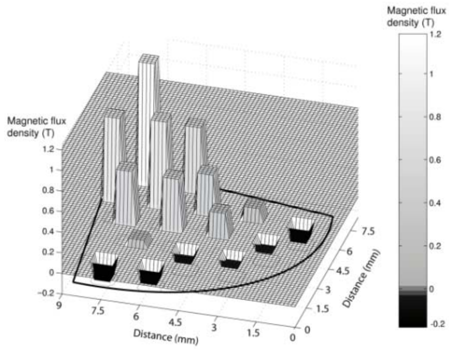




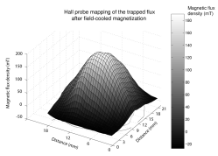
Decreasing part of the pulse

- spatial variations along the radius smaller on the surface than in the median plane
- larger maximum trapped flux in the median plane
- no negative trapped flux on the surface in the peripheral holes

Trapped magnetic flux in the median plane



Hall probe mapping



- smaller trapped flux than in the median plane
- no negative trapped flux at the periphery

- max trapped flux in the median plane : 1.18 T
- max trapped flux on the bottom surface : 545 mT

➡ **Ratio : 2.17**
Consistent with simulation data

Conclusion

We use the holes in a drilled YBaCuO cylinder to probe the local magnetic flux density in the median plane and on the surface of the sample, during a pulsed-field magnetization. This technique enables us, for the first time, to characterize the flux propagation in the bulk of the sample, instead of above its surface as is the case with conventional field mapping techniques. In particular, the trapped magnetic flux density in the median plane has been shown to be almost twice that measured at the surface.

Acknowledgments

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