Hole lattice influence on the magnetization of drilled superconductors

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Introduction

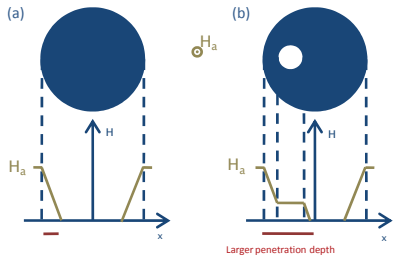

Fig.1 : Penetration of the magnetic field (Bean model) in a bulk (a) and in an infinitely extended cylinder with one hole (b).

Drilling **a single hole** in bulk superconductor samples favours oxygen annealing and ensures a good thermal stability. Nevertheless, the hole also affects the magnetization of such samples. For instance, the penetration depth of a uniform magnetic field in an infinitely extended cylinder is larger if there is one hole (see Fig. 1). As a result, the bulk magnetization M of the drilled sample is modified, leading to a magnetization drop ΔM,

$$M = \left(\frac{1}{S}\int H_z dS\right) - H_a \quad \Rightarrow \quad \Delta M = \frac{M_{(a)} - M_{(b)}}{M_{(a)}}$$

In this work, we study the influence of a **hole lattice** on the magnetization with the help of a specific numerical algorithm for calculating the magnetic field distribution inside drilled samples. In particular, we seek to optimize the magnetization of drilled samples by modifying the lattice parameters.

Modeling the magnetic field penetration in drilled samples

Basic assumptions

- Bean Model $\frac{dH}{dl} = J_c$ l: total distance traveled by the flux front
- Field can reach the point P
  1. directly from the border (l=x)
  2. via a hole acting as a *radial source* (l=D+r)

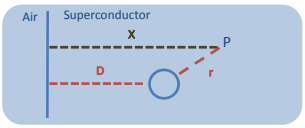

Fig. 2: Schematic view of both penetration paths in a semi-infinite plane with one hole.

Algorithm main principle

The flux front travels along the *shortest* path

$$l = \min(X, D+r)$$

Current lines discontinuities

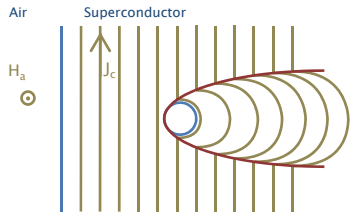

Fig.3 : Calculated current line distribution in a semi-infinite plane with a hole.

Semi-infinite plane

- Optimization of two-hole angular location

*The magnetization drop ΔM is minimized when the second hole is located **on the discontinuity parabola** of the first one.*

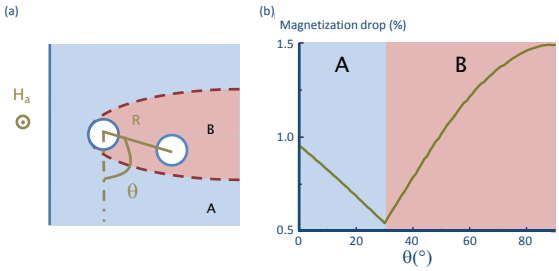

Fig.4 : Magnetization drop (b) in a two-hole semi-infinite sample submitted to a uniform applied magnetic field (a) as a function of the relative angular position of the holes (kept as a constant distance R) .

Cylinder with an infinite extension

- Influence of the lattice type

*The magnetization drop is minimum in a **polar triangular** lattice configuration*

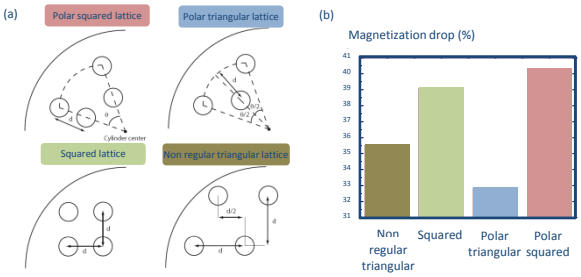

Fig. 5: Magnetization drop (b) for different lattice configurations (a) in an infinitely extended cylinder.

- Optimization of lattice (non regular triangular case)

*Lattices with a **large number of holes of small radius** optimize the magnetization*

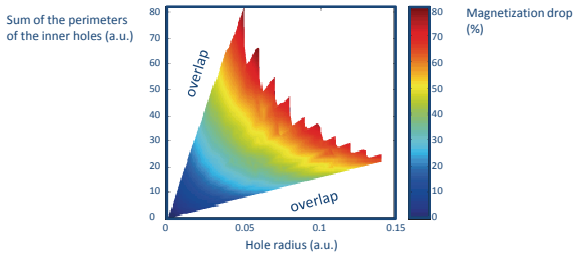

Fig. 6: Magnetization drop as a function of the hole radius and of the sum of the perimeters of the inner holes in an infinitely extended cylinder. The holes are arranged in a non regular triangular configuration.

Conclusion

The influence of the hole lattice parameters on the magnetization of drilled superconductors has been studied by a specific algorithm based on the Bean model. In particular, we give some means of optimizing the magnetic properties of drilled samples :

- the holes have to be located on the discontinuity parabola of one another, like in triangular lattices,
- for a constant circumference length of the inner holes, a lattice with a large number of small holes is preferable.

Acknowledgments

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