Electronics

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supratecs – Services of the University Performing Research and Applications in the Technology of materials : Electroceramics, Composite and Superconductors

Introduction

The research carried in the group is dealing with **modelling the physical phenomena basic to electronics**.

We study the properties of **different materials**:

- **high-Tc superconductors** (‘zero’ DC electrical resistivity, low AC losses, strong diamagnetic response) ,
- **semiconductors** (transport of spin and charge, optical response),
- **hybrid systems**: combinations of
  - superconductors and ferromagnetic materials,
  - superconductors and magnetic semiconductors.

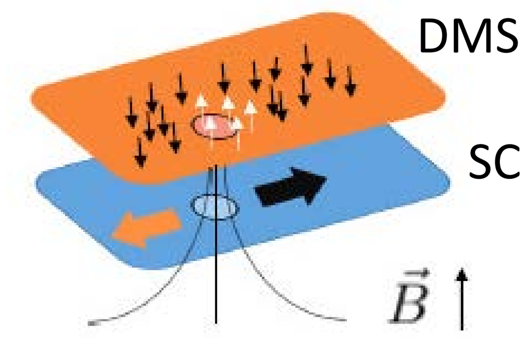
Our activities aim at **developing models**, which can be analytical or numerical (Green functions, FEM methods). They take into account the magnetic, electrical, and thermal properties, as well as their interactions (multiphysical aspects).

We oftentimes work in close connection with experimental or characterization work, in order to provide a better insight of the underlying physics and help in optimizing the application.

Main applications

- **Magnetic shielding** with superconductors.
- **Trapped field magnets** with superconductors.
- Thermomagnetic phenomena in bulk superconductors for:
  - **reducing the thermal losses** and better controlling the heating mechanisms
  - **controlling the heat tranfer** to a liquid coolant.
- **Transport of spin and charge** in diluted magnetic semiconductors.
- Coupling the magnetic properties of superconducting films and diluted magnetic semiconductors for the **design of new nanoscopic electronic devices**.

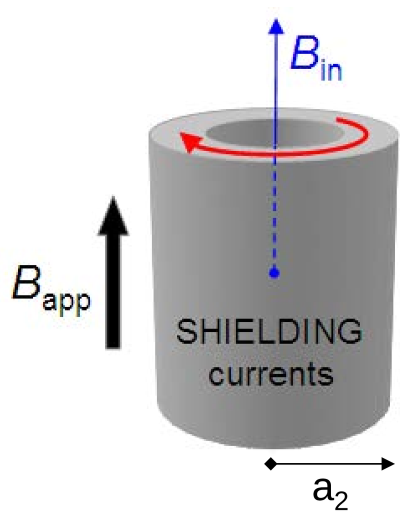
New nanoscale devices



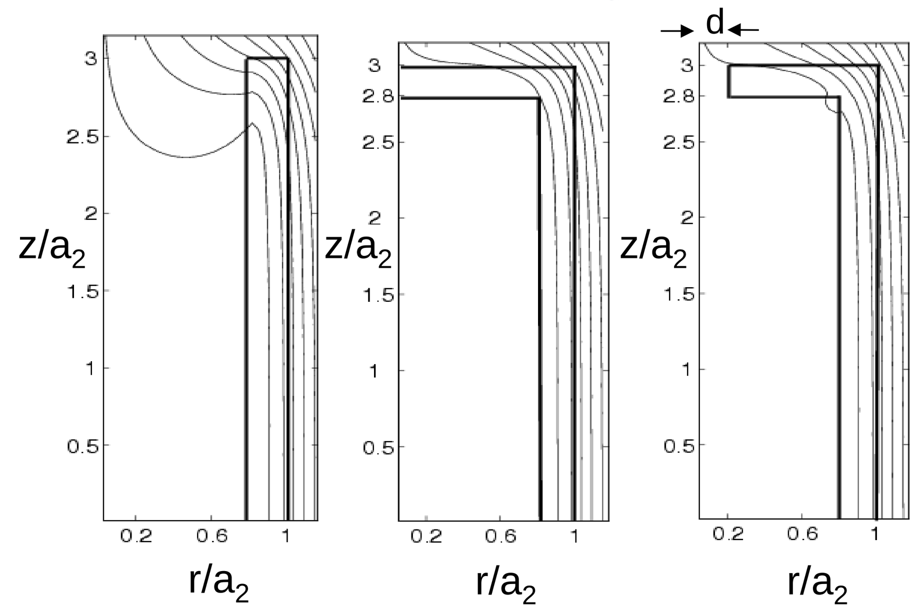
A superconducting film (SC) is placed under a film of a diluted magnetic semiconductor (DMS). The stray magnetic field from the superconductor layer (e. g. from vortices) induces a local polarization of the spins of carriers in the semiconductor. Hence, the transport of spins in the DMS can be controlled by manipulating the magnetic flux in the SC.

Ongoing work, SPINTWEAKS project

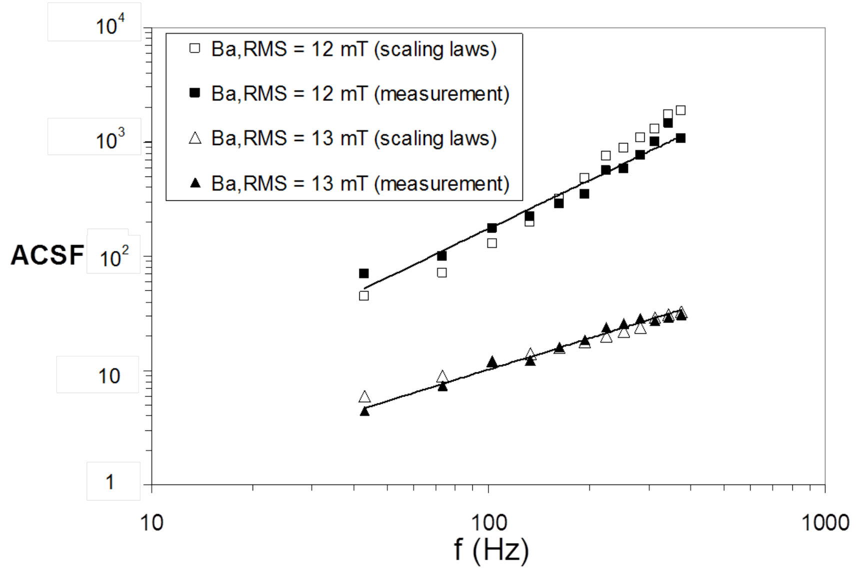
Magnetic shielding with bulk superconductors



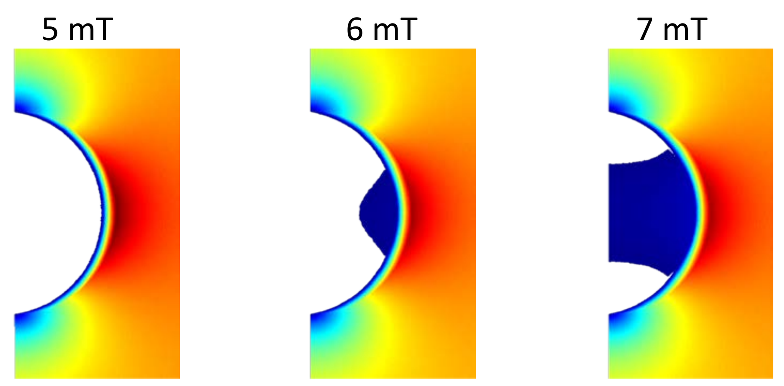
Shielding with a tube



Effects of different magnetic caps on the penetration of the magnetic flux



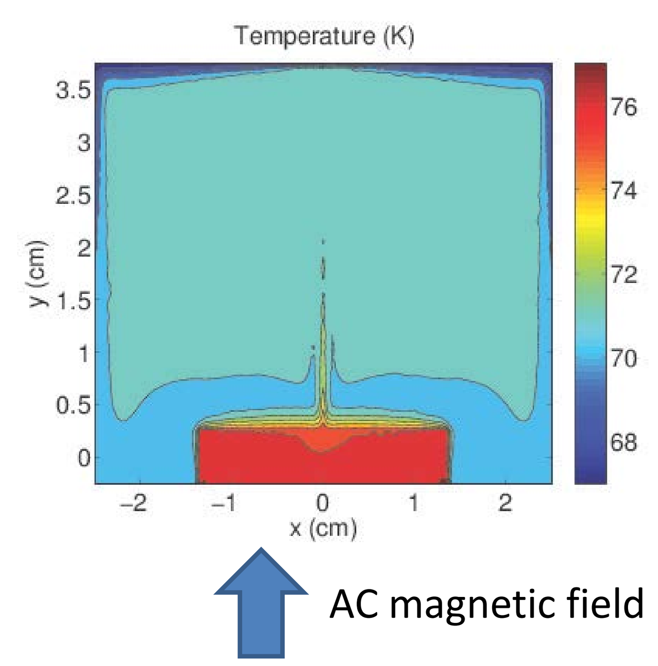
Checking for the theoretically expected scaling laws

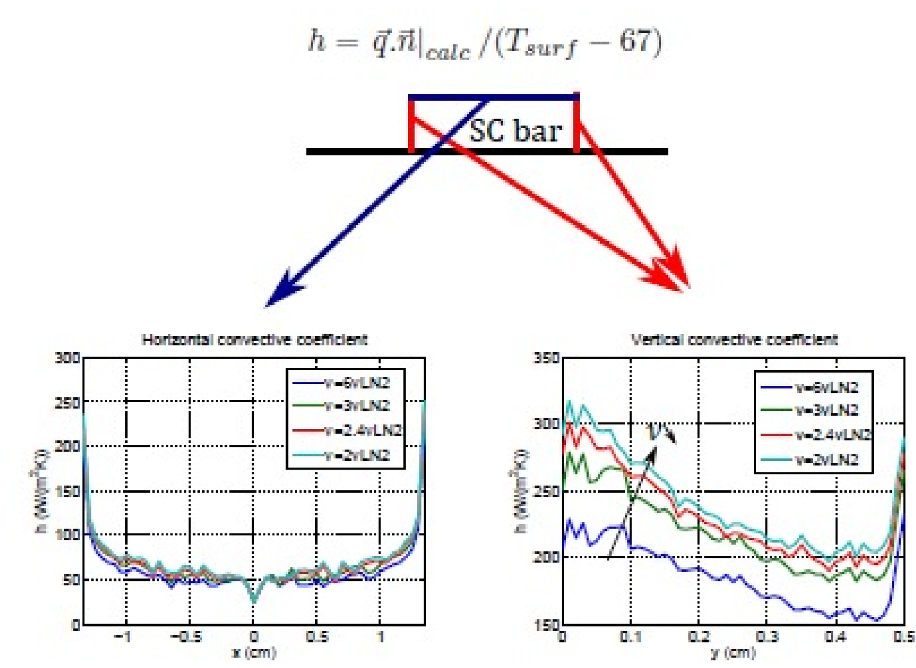


Investigating the demagnetization effects for a spherical shield

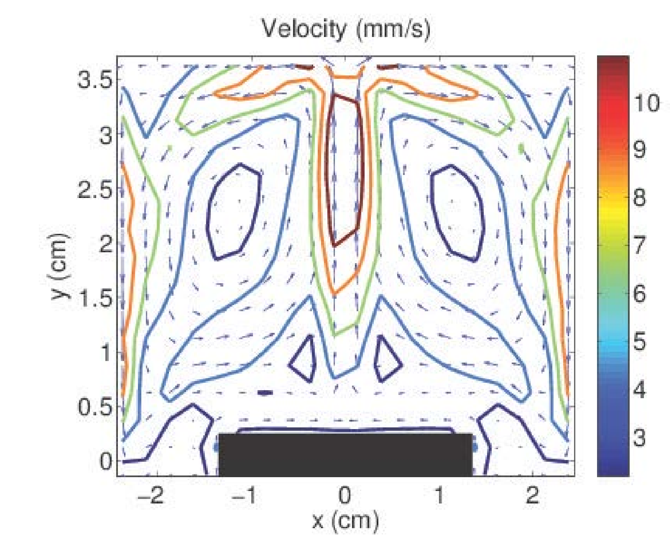
See for instance: S. Denis et al., Superconductor Science and Technology (2007), 20(3), 192-201 ; Superconductor Science and Technology (2007), 20(5), 418-427

AC losses in superconductors and heat transfer to a liquid coolant





A superconductor subjected to an AC varying magnetic flux will experience self-heating losses. Understanding the heat tranfer to a liquid coolant is important in order to design better cooling systems and avoid an unnecessary degradation of the superconducting properties.



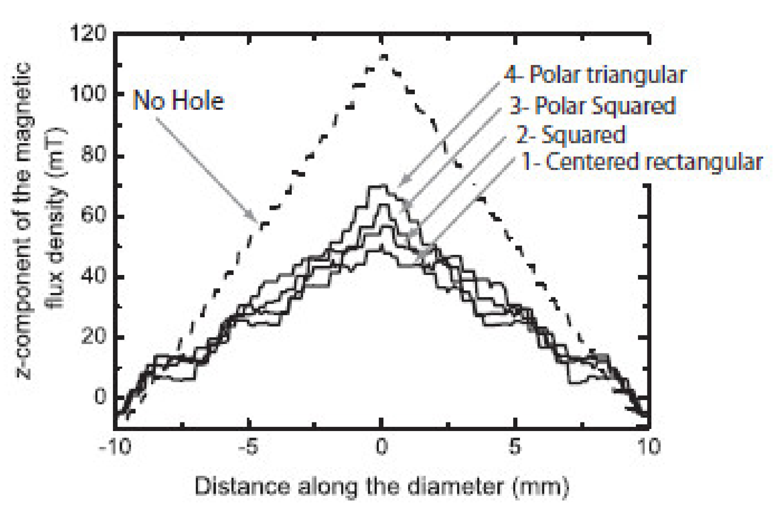
Ongoing work, SUPERCOOL project

Trapped magnetic fields

Strong magnets for MAGLEV

magnetic levitation train

(magnets of several teslas!)



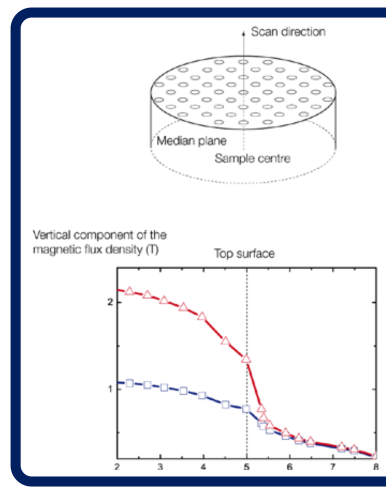
Profile for the trapped magnetic field

Bulk superconductors are used for trapping a high magnetic flux (record inductions of 17.6 T can be trapped!). In the case of thin wall superconductors, the pellet contain an array of columnar holes to assist the diffusion of oxygen during the synthesis. The array can be shaped in order to maximize the magnetic flux trapped in the pellet.

Square | Centered rectangular | Polar triangular | Polar square

See for instance: G. Lousberg et al., Superconductor Science and Technology (2009), 22

Hybrid systems



Left: magnetic field trapped in a supercond. pellet with holes filled with a soft ferromagnetic material.

Right: electric properties of a supercond. wire with a metallic sheath.