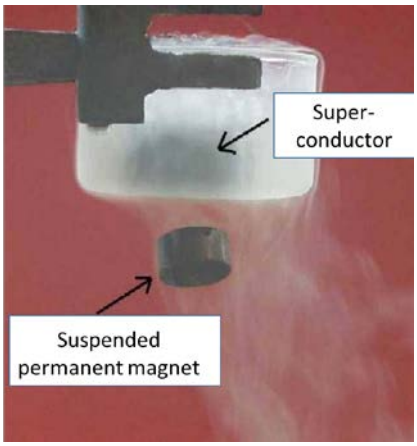
Master thesis in the "Measurement & Instrumentation" laboratory (2016-2017)

Design and construction of a multi-sensor magnetic torque measurement system at cryogenic temperature ; application to trapped-field superconducting magnets

Context :

Superconductors are materials that are able to carry large currents without any electrical resistance at very low temperature, e.g. at the boiling temperature of liquid nitrogen (77K). Thanks to the remarkable behaviour of magnetic flux lines in these materials, they are also able to trap significant magnetic flux densities (exceeding 2 teslas). These properties can be exploited for stable levitation or suspension between a superconductor and a permanent magnet (cf. photograph) or for new powerful rotating machines. The parameter of interest for designing a superconducting motor is the magnetic torque experienced by the superconductor when it is subjected to a magnetic field at a given angle with respect to its magnetization. Most cryogenic torque magnetometers, however, accommodate generally small samples (< 1 mm^3). The purpose of the present work is to design and construct a magnetic torque measurement system that would be able to probe the magnetic properties of larger samples (~ 1 cm^3) that can be used in rotating machine applications.



Description of the work :

The master thesis work consists in designing and realising an experimental setup based on several sensors (strain gauges, angular position, temperature sensors, Hall effect sensors) allowing the magnetic torque of a permanent superconducting magnet to be measured in cryogenic conditions. The system will be used for characterize the performance of superconductors when they are subjected to magnetic fields that are not parallel to their magnetization, in view of novel rotating machine applications. The work consists in choosing the sensors adapted to low temperature torque measurement and in designing (i) the torque sensor, (ii) a rotating sample holder controlled by a stepper motor and (iii) the measurement of the signals given by the sensors used for probing the material properties when it is placed in various magnetic field configurations. Measurements will be carried out on commercial superconductors (Nippon steel and Sumitomo Corporation, Japan) or obtained through international collaboration (Cambridge University, UK). This work, involving a strong experimental part, will be carried out in the "Electronics, Microsystems, Measurements & Instrumentation" laboratory.

Profile : electrical engineering, mechanical engineering or physics engineering.
The candidate should have a strong interest for experimental work

Co-requisite : ELEN 0047 "Superconductivity" (P. Vanderbemden), organised during 1st quadrimester of the academic year.

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