Superconductivity: wires and electromagnets

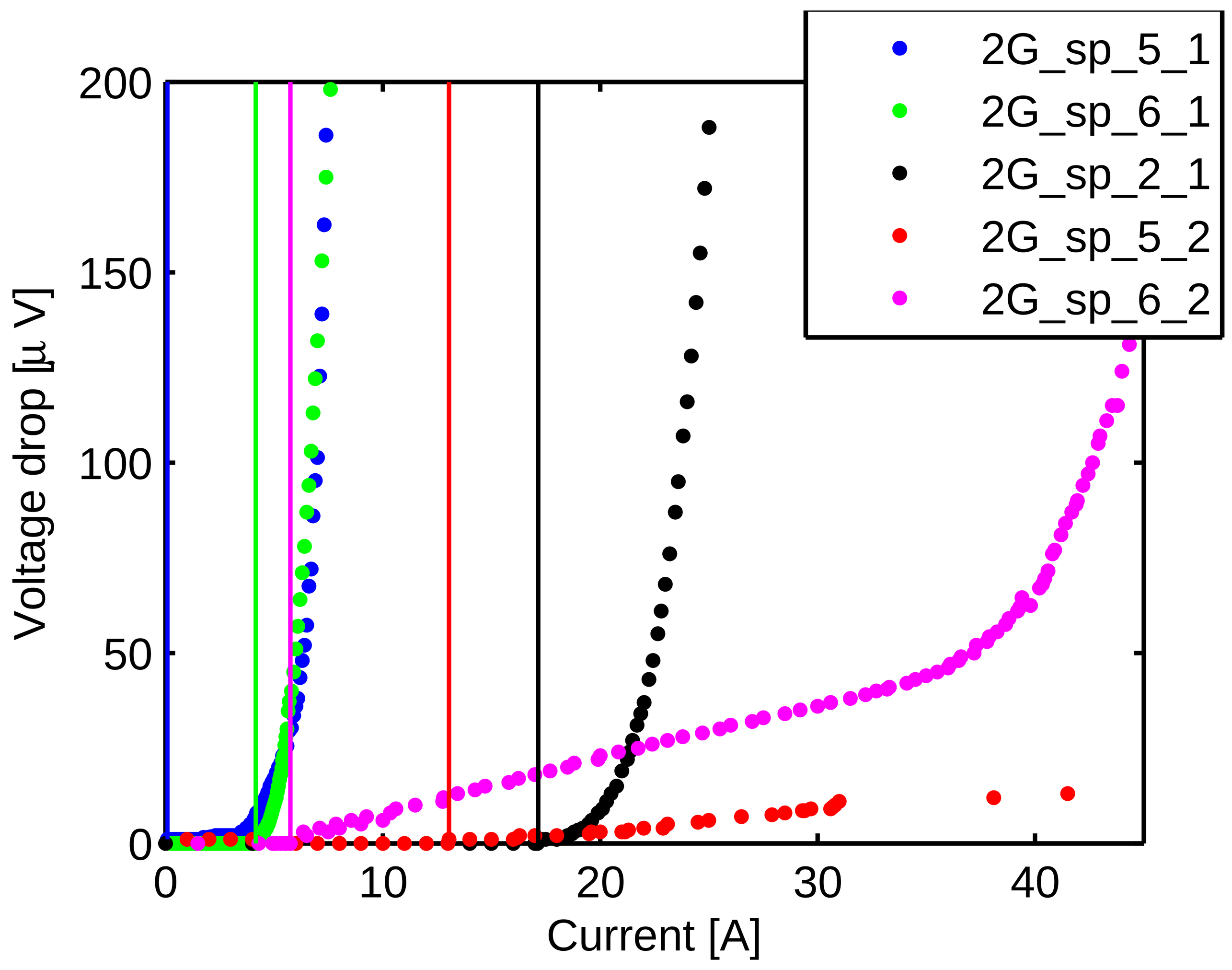
Adrian Szeliga, Poland

IFJ PAN, AGH UST

About author

My name is Adrian and I am 24 years old. I came from Poland and I live there. I am a design engineer in Division of Scientific Equipment and Infrastructure Construction (DAI). DAI is a part of The Henryk Niewodniczanski Institute of Nuclear Physics Polish Academy of Sciences (IFJ PAN) in Cracow. I have graduated this year. I was studying Applied Physics at AGH University of Science and Technology in Cracow.
I am interested in superconductivity and its applications.
For my both thesis (bachelors and masters) I was examining properties of high temperature superconducting tapes. I was measuring critical currents, temperatures and a few things more. I built two superconducting coils. First one - solenoid - with magnetic field density $B = 12$ mT and the second - Helmholtz's coil - with $B = 78$ mT, when they were supplied with 50 A.

Me



Superconductivity

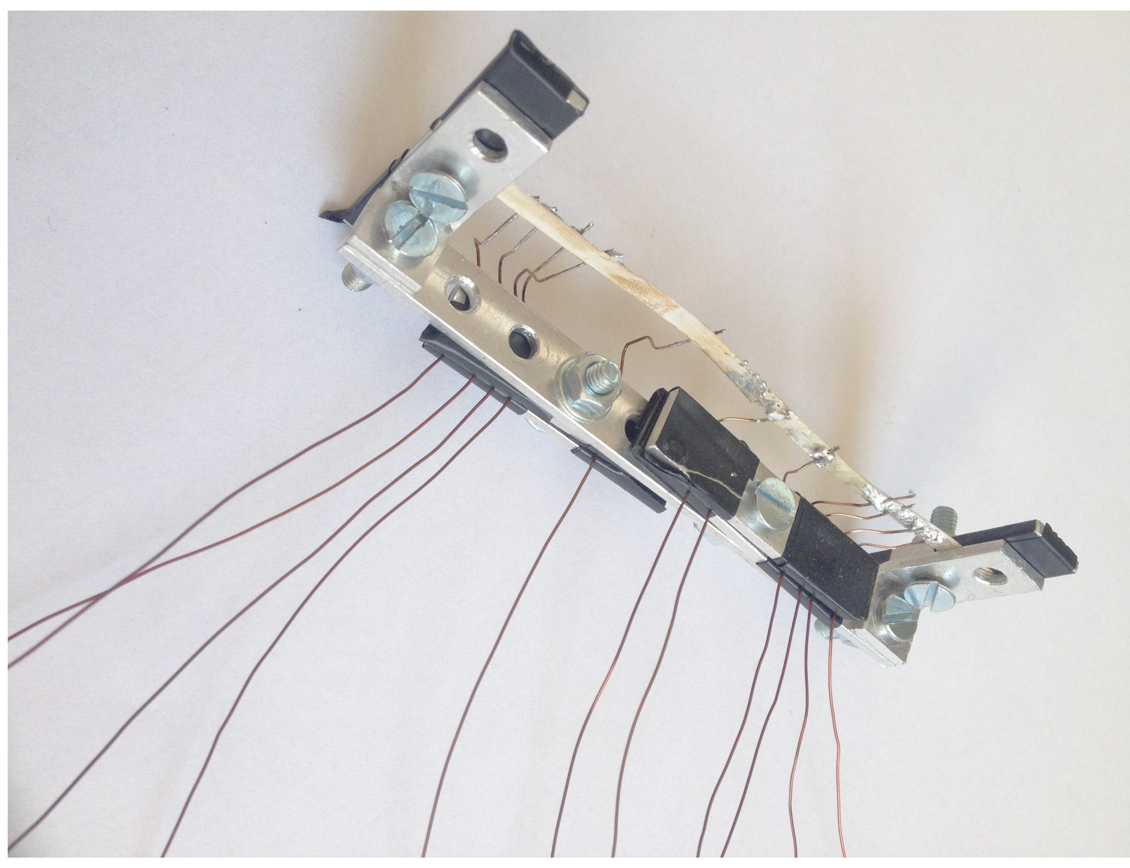
One of the basic properties of superconductors is critical current density. It is connected by Maxwell's equations with another basic property - critical magnetic field intensity. Existence of the second one can be explained in following way: in superconducting state they are two types of electrons - normal and superconducting. Magnetic field rises energy density of the superconducting ones, that there is a field intensity when superconducting state is no longer beneficial for the material.

Measurements of critical current

On the left one can see voltage drop measured on the 2G superconducting tapes using a 4-probe method. When a superconductor reaches its current limit, a resistance rises very quickly. The vertical lines point places, where voltage drop rises above 0 μV, but this is not always the critical current. Sometimes a part of the current flows through a silver part of the tape and shows linear ohmic resistance even if the tape is superconducting.

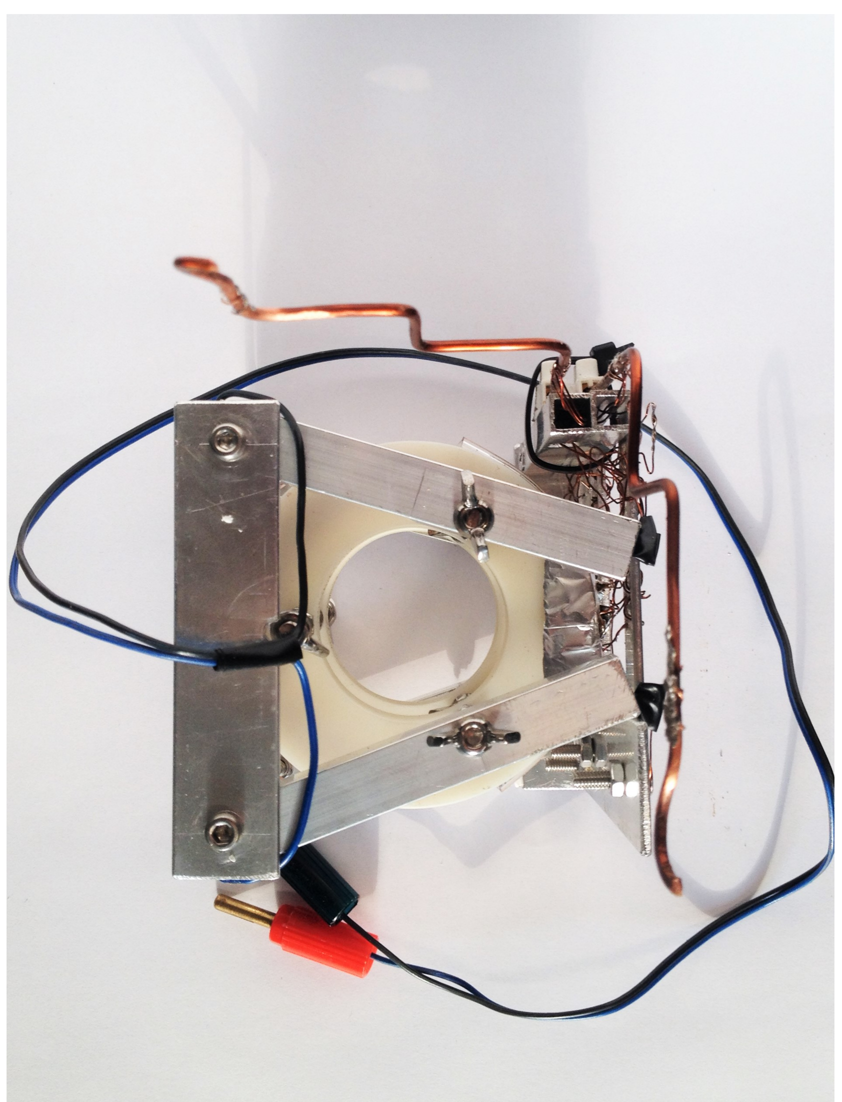
Wires

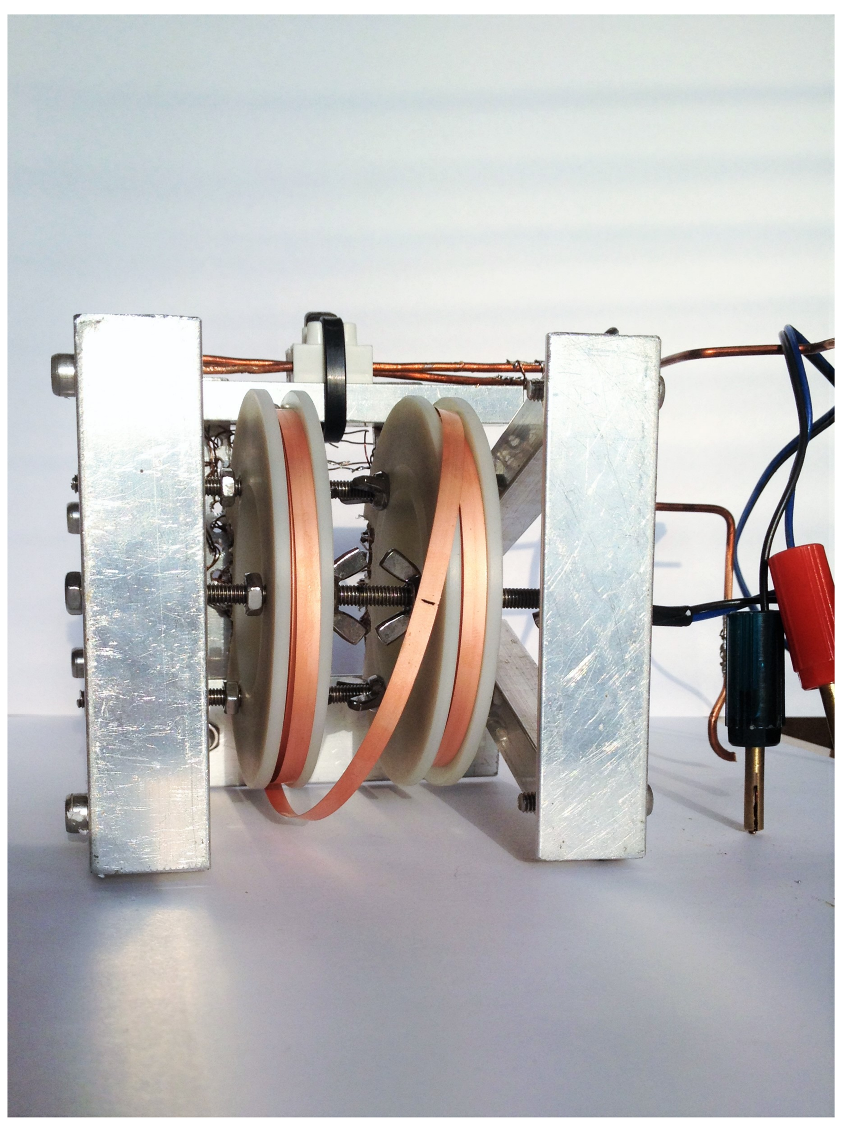
In these days, when superconductors have many applications it is obvious that there is a need two join two superconducting wires to make a circuit. Technology of jointing low temperature superconductors is mastered. Unfortunately, high temperature superconductors, which operate at temperature of a liquid nitrogen, are almost impossible to be joined without resistance.



Joint performance

On the right one can see a system for measuring a performance of the joint attached to wall to focus your attention. 8 wires on both sides supply current. 3 wires in the middle measure a voltage drop on the joint, and on the tape as a reference point. Joint of the HTS tape was made with a special soldering machine and solder.





Electromagnets

On a side, on the two pictures there is a superconducting Helmholtz's coil, designed and built by myself, presented. On the left one can see the inner working area, thick copper wires as the current leads and the blue/black cable for measuring a voltage drop. On the second one can see the superconducting tape and the place when the coils are joined or rather when the tape is not split. ;)

[1] A.C. Rose-Innes and E.H. Rhoderick. *Superconductivity*. 1973.

[2] G.D. Brittles et al. "Persistent current joints between technological superconductors". In: *Superconductor Science and Technology* (2015).

e-mail `adrian.szeliga@ifj.edu.pl`
IFJ PAN web `www.ifj.edu.pl`
AGH UST web `www.agh.edu.pl`