Open Material Property Library With Native Simulation Tool Integrations – MASTO

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25^{th} International Conference on Magnet Technology
Amsterdam, The Netherlands

Contents

Introduction

- Simulations are crucial for designing new (superconducting) devices
- *Carbage in* leads to *carbage out*: material properties play essential role in all simulations
- Superconducting devices use special materials at extreme conditions
- Material characterization is time consuming, it is more efficient to use material property databases, especially when desingin something new

A case study: How material properties can influence on the simulation results?

- Adiabatic heat conduction equation can be utilized to estimate the *upper limit* of the hot spot temprature T_{hs} in a superconducting magnet during a quench (the MIITs approach)

$$c\frac{\partial T}{\partial t} = \rho\left(\frac{I}{A}\right)^2$$

$$\Rightarrow$$

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- Practical way: current decay curve is easy to measure, c and ρ are averaged over magnet's unit cell

Comparison of three different material property databases

- Cryogenic Technologies Group at National Institute of Standard and Technology, US (NIST)
- MATPRO: A Computer Library of Material Property at Cryogenic Temperature, Italy (MATPRO)
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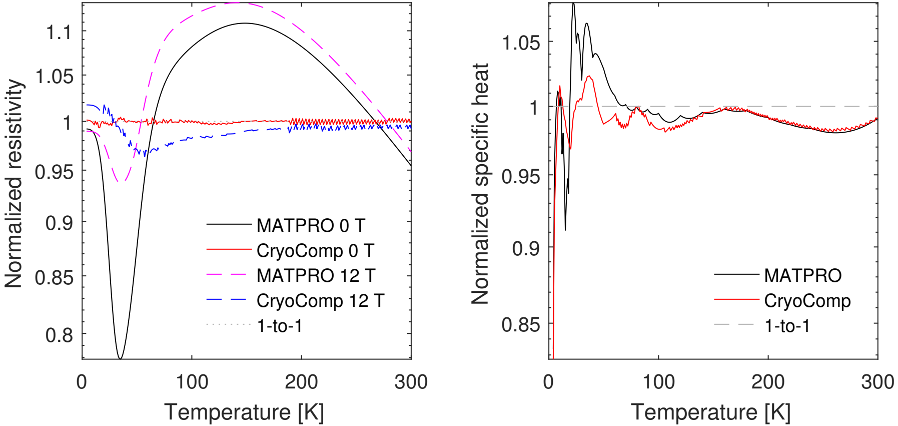
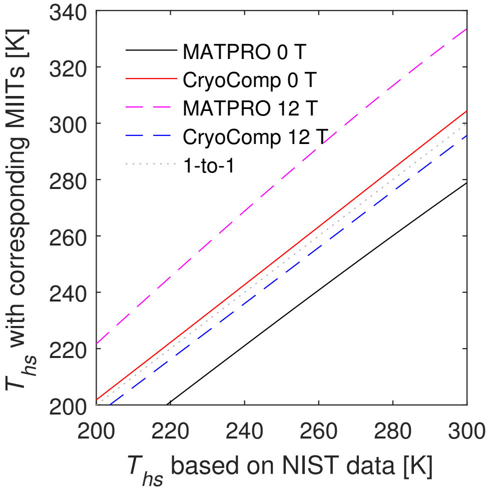
To simplify, we study only RRR=100 copper at 0 and 12 T and $T_{op} = 4.2$ K and take c and ρ from NIST, MATPRO and CryoComp. We consider how the predicted T_{max} varies between the materials taken from different databases.

Variation in material properties



Variation in predicted T_{hs}



- 0 T:
  NIST $\rightarrow$ 300 K
  Corresponds to
  MATPRO $\rightarrow$ 279 K
  CryoComp $\rightarrow$ 304 K
- 12 T:
  NIST $\rightarrow$ 300 K
  Corresponds to
  MATPRO $\rightarrow$ 334 K
  CryoComp $\rightarrow$ 296 K

Remarks

- Selection of material property source can have large influence on the simulation results
- When devices are designed to the limits, the uncertaintity related to the material properties can even prevent some solutions
- It is important to run simulations with data from several sources to get estimation of the material uncertainty

- Material property data is scattered $\rightarrow$ it requires effort to implement different material properties in a simulation tool

Centralized effort to create material property database

- We have started to develop a centralized database for material property data called

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> Open Material Property Library With Native Simulation Tool Integrations – MASTO

- MASTO is an effort to build "social media" platform around material properties
  - Find materials and their data for your projects
  - Use material property data easily with simulation software
  - Upload your own material property data
  - Find people to characterize your material
  - Find experts for your open positions

Important questions for such a database are

- How to ensure that no one is blocking another one for entering similar data?

> I have my copper, but perhaps you want to have your copper too.

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> Social media is full of all kind of non-verified propaganda, but even there are some means to verify, at least, the sender.

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- How to ensure the persistence of data?

> When data is utilized in a modelling tool as a dependency, the tool must not break in the future.

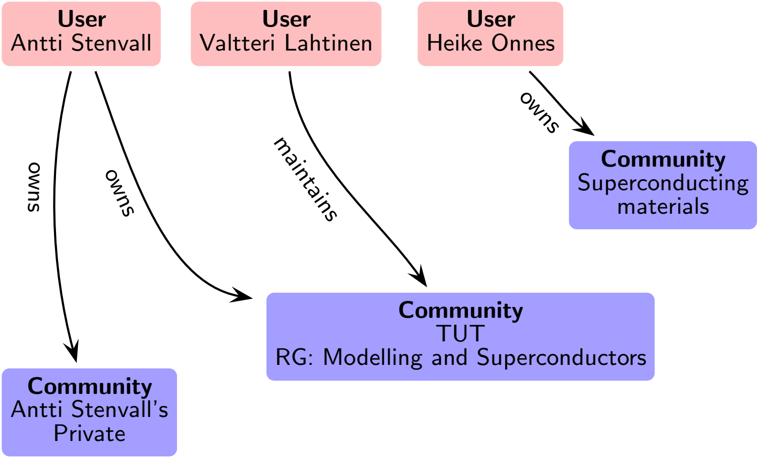
Schematic of organizing the data

User
Antti Stenvall

User
Valtteri Lahtinen

User
Heike Onnes

Schematic of organizing the data



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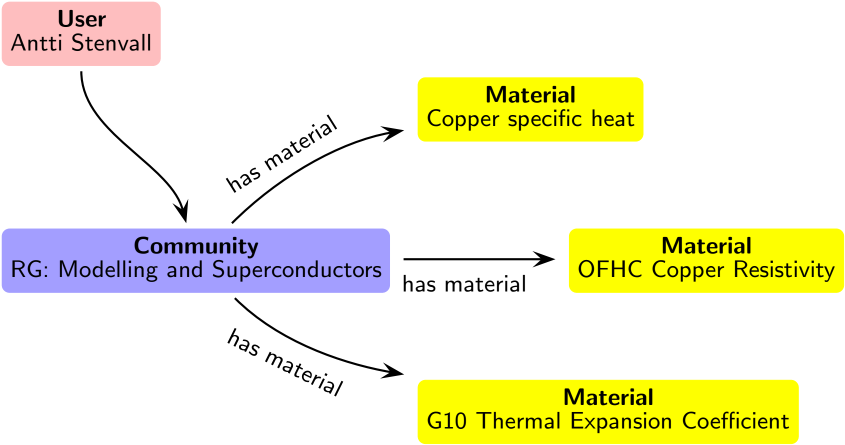

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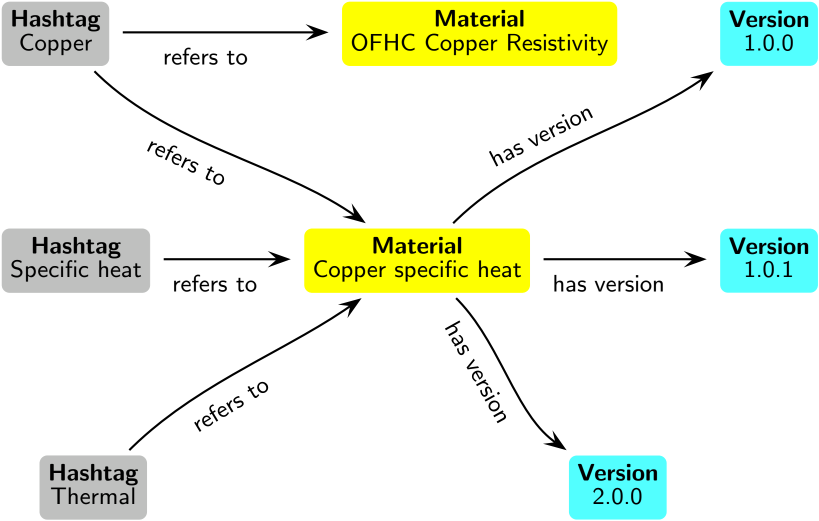

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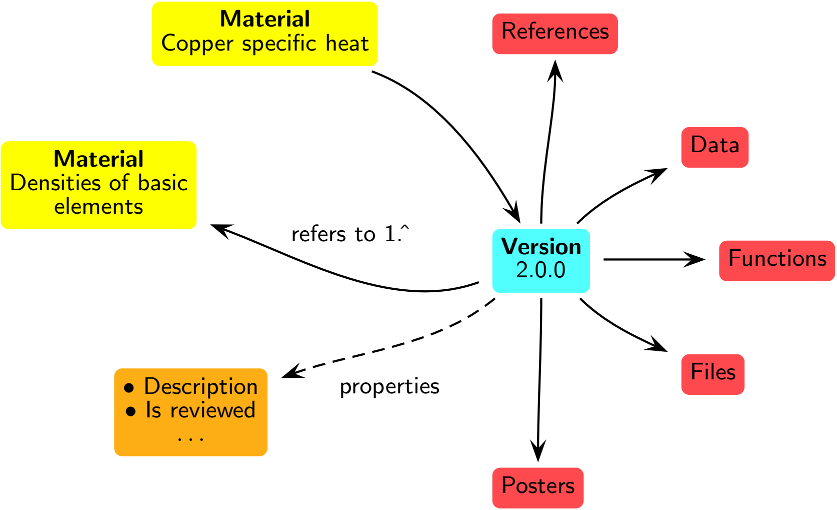

Simple to use Matlab integration

- With your mobile phone, go to page `http://dev.masto.eu.com`
- Type `Cu` and click search
- Select `Copper specific heat (NIST data)`
- How do we use this data in Matlab?
- In Matlab (after running an initialization script, must be done only once)
  - Require local copy:
    ```
    masto.stenvala.utils.latest.require('stenvala',...
    'copper-specific-heat-nist')
    ```
  - Use:
    ```
    T = linspace(0,300);
    C = masto.stenvala.copperSpecificHeatNist.latest(T);
    figure(1);
    plot(T,C);
    ```
  - Nothing else needed!

Conclusions

- We showed that material property data source can influence notably the simulation results (MIITs around 300 K varied at most 34 K in a particular case)
- To get somekind of an understanding about the sensitivity of results to data, it is good to use different data sources
- We introduced an ongoing effort to build a "social material property" platform **MASTO** where
  - the *material property data* is at the core
  - anyone can import data
  - data can be easily utilized with Matlab with no re-programming effort (and in the future with other tools too)
  - experts can find each other
  - no funding is currently available, but first application will be sent on September

Thank you for your attention