Universität Rostock

Traditio et Innovatio

# Master Thesis

# Impact of Uncertainties on Performance of QPR under Electro-Stress-Heat Coupling

## Project description:

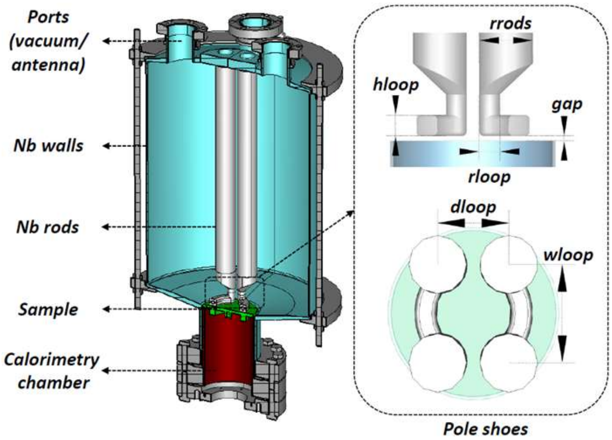
Quadrupole resonators have been used since the 1990s to determine the properties of metal samples in superconducting radio frequency (SRF) applications. They allow for analyzing planar, metallic samples by a calorimetric measurement. Such an experimental setup is shown in below figure. Four metallic rods are located in a cylindrical resonator. The bars are shorted in pairs at both ends. The short circuit of the bars is referred to as the pole shoes. Under the pole shoes, the sample is mounted on a replaceable cylinder. If an antenna then excites an electromagnetic field with the desired frequency between the rods, they form a quadrupole-like magnetic field under the pole shoe on the surface of the sample [1]. The cylinder on which the sample is applied and the resonator are thermally separated. The sample is kept at a constant temperature from the bottom by a heating controller. If a magnetic field is now applied to the sample through the pole shoe, a power loss arises there. As a result, the heating controller consumes less electrical power because the sample is heated by the losses. Due to the difference in the electrical power, the surface resistance can be calculated very accurately. In this master thesis a novel quadrupole resonator based on the current design of the Helmholtz-Zentrum Berlin (HZB) is to be designed. The insist will be put on mimicking manufacturing imperfections, which affect both geometrical and material parameters, by means of the uncertainty quantification.

The tasks of the student would at least comprise the following steps:

1. Student has to first conduct a study on the fundamental principles of quadrupole resonators. This includes a literature study.
2. Next, the coupled electro-stress-heat model of the QPR needs to be implemented and parameterized in in the COMSOL.
3. Due to the production imperfections certain geometrical and material parameters are uncertain. Thus, their variations are modelled using the polynomial chaos (gPC) expansion technique [4]. As a result, the obtained solutions can be represented by convergent series of the PC in terms of the input random parameters.
4. A suitable post processing tool in the form of the global sensitivity analysis (GSA) should be used to verify, which parameter have the most important impact on the output functions.
5. Optionally, the modified structure of the QPR can be proposed based on the GSA.
6. Documentation of the work, including an introduction, theoretical foundation and explanation of the results.

## References:


1. R. Kleindienst et al., “COMMISSIONING RESULTS OF THE HZB QUADRUPOLE RESONATOR”, Proceedings of SRF2015, Whistler, BC, Canada, 2015.
2. R. Kleindienst., “Radio frequency characterization of superconductors for particle accelerators”, PhD thesis, University of Siegen, Siegen, 2017
3. .S. Keckert, et al. The challenge to measure nΩ surface resistance on SRF samples, IPAC 2018, Vancouver, BC, Canada.
4. P. Putek, S. Gorgi Zadeh, M. Wenskat, W. Hillert, U. van Rienen, Ursula, “Uncertainty Quantification of a Quadrupole-Resonator for radio frequency characterization of ssuperconductors” In Proceedings of SRF, Dresden, Germany, 2019



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