Implementation of an Eigenfrequency-Based Deformation Identification for RF Cavities

TECHNISCHE UNIVERSITÄT DARMSTADT

Proposal for a Bachelor's thesis | Seminar topic
Study field: Computational Engineering | Electrical Engineering | Mathematics
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Description

In particle accelerators, commonly multi-cell resonating structures are used, e.g. the superconducting 9-cell TESLA cavity. Such devices are manufactured from niobium sheets which are deep-drawn and welded together, see Figure 1. During this welding process, misalignment occurs at the joinings of the individual components, which leads to deviations from the desired eigenfrequencies and field patters, which negatively influences the accelerating performance of the electromagnetic cavities.

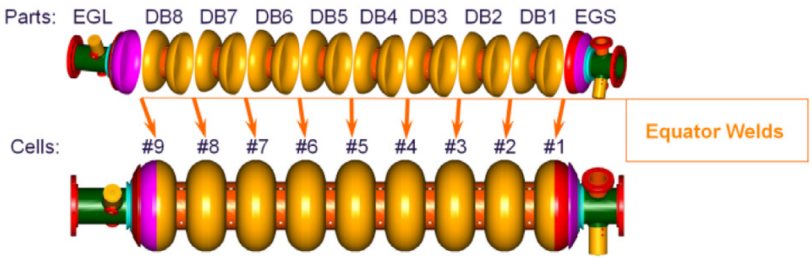

Figure 1: The cavity is manufactured by welding from 10 parts, i.e., two end-groups (EGL, EGR) and the eight dumb-bells (DB) [1].

In order to quantify these uncertainties, the works of [2] examined 700 observations available from measurements at Deutsches Elektronen-Synchrotron (DESY) and found seven uncorrelated deformation variables to describe the cell misalignment.

The purpose of this thesis is to develop an optimization algorithm which allows for conclusions from the measured eigenfrequencies to the deformations of the cavity under consideration. To this end, the closed-form sensitivities with respect to the deformation variables should be used, see [3]. Using these, an efficient optimization routine should be implemented to identify the misalignment.

Work plan

- Study the literature on the manufacturing of the cavity and the optimization.
- Study the existing Matlab Code.
- Formulate and implement the optimization problem for the deformation identification.
- Compare different regularization techniques.

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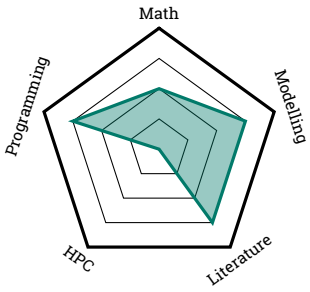
Weighted Core Areas:



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Prerequisites

- Programming skills in Matlab.
- Knowledge of the finite element method and/or mathematical optimization is beneficial but not necessary.

References

[1] Corno, Jacopo; Georg, Niklas et al.. *Uncertainty modeling and analysis of the European X-ray free electron laser cavities manufacturing process.* Nuclear Inst. and Methods in Physics Research, 2020, Vol. 971.

[2] Georg, Niklas; Ackermann, Wolfgang; Corno, Jacopo; Schöps, Sebastian. *Uncertainty quantification for Maxwell's eigenproblem based on isogeometric analysis and mode tracking.* Comput. Meth. Appl. Mech. Eng., 2023, Vol. 350, pp. 228-244.

[3] Ziegler, Anna; Hahn, Robert; Isensee, Victoria; Nguyen, Anh Duc; Schöps, Sebastian: *Gradient-Based Eigenvalue Optimization for Electromagnetic Cavities with Built-in Mode Matching.* Cornell University, ARXIV: 2310.15751. 2023. Preprint.

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