# Eigenmode Computation for Biased Ferrite-Loaded Cavity Resonators*

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## Introduction

In the heavy-ion synchrotron SIS 18 two ferrite-loaded cavity resonators are operated for the further acceleration of charged particles. Since the speed of the heavy ions still increases significantly during the phase of acceleration, the operating frequency of the resonator has to be adjusted to the revolution frequency of the particles. To this end, dedicated biased ferrite-ring cores are installed together with the necessary current windings. Modifying the bias current results in an altered differential permeability of the ferrite material and finally enables to adjust the resonance frequency. The current study aims at the numerical computation of the lowest eigenmodes for biased ferrite-loaded cavity resonators.

## Computational Approach

The fundamental relations relevant for the calculation of eigenmodes of biased ferrite cavities as well as the used computational model are discussed in [1]. To sum up the most important aspects briefly, the eigenfrequencies strongly depend on the magnetic properties of the ferrite material and particularly on its differential permeability at a given bias magnetic field. Hence, to determine the eigenmodes the bias field is calculated in a first step by means of a nonlinear magnetostatic solver. After linearizing the constitutive equation at this working point, the actual eigenmodes are computed by the subsequent solver (cf. fig. 1). Due to the frequency dependence of the permeability tensor, the eigenvalue problem is nonlinear. Additionally, the system matrix is non-Hermitian if magnetic losses are taken into account. Besides of that, the newly developed solver is designed for an efficient computation on distributed memory machines.

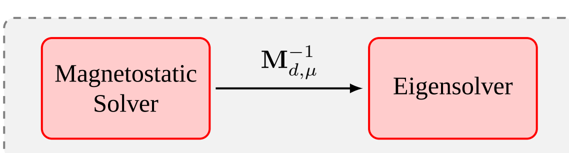


Figure 1: Subcomponents of the solver. Due to the dependence of the differential permeability $\mathrm{M}_{d,\mu}$ on the bias magnetic field, the magnetostatic field problem has to be solved before computing the actual eigenmodes.

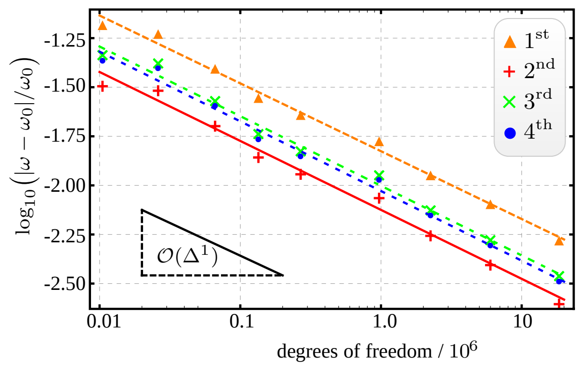


Figure 2: Relative deviation of the numerically obtained value $\omega$ to the semi-analytical result $\omega_0$ as a function of the degrees of freedom for the four lowest eigenfrequencies for a lossless, ferrite-filled cylindrical cavity resonator (radius $= 1$ m, length $= 2$ m, $\mu_r = 7$, $H_{\mathrm{bias}} = 2750$ A/m) [1].

## Numerical Example

To verify the nonlinear eigensolver, a lossless, ferrite-filled cylindrical cavity resonator longitudinally biased by a homogeneous static magnetic field is considered, for which the solutions can be found semi-analytically [2, 3]. Performing convergence studies with different numbers of degrees of freedom, ensures a proper implementation of the underlying algorithms while good accordance of numerically obtained results with the reference values is observed (cf. fig. 2).

## Summary and Outlook

A new solver for the determination of eigenmodes of biased ferrite-loaded cavity resonators is developed. Whereas promising results for simplified lossless resonators have been presented, the support of lossy material is currently in progress. Future work will also include the reliable implementation of the magnetic properties of the ferrite material installed in the SIS 18 cavities.

## References

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* Work supported by GSI
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