SPECTRAL SENSITIVITY ANALYSIS OF ELECTROMAGNETIC CAVITIES

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The study of electromagnetic cavities has many real world applications, for example in designing cavity resonators or shielding structures for electronic circuits.

In this talk we consider the following eigenvalue problem arising from time-harmonic Maxwell's equations

$$\begin{cases} \operatorname{curl}\operatorname{curl} u = \lambda\, \varepsilon\, u & \text{in } \Omega, \\ \operatorname{div} \varepsilon u = 0 & \text{in } \Omega, \\ \nu \times u = 0 & \text{on } \partial\Omega. \end{cases} \tag{1}$$

Here Ω is a bounded domain in $\mathbb{R}^3$ and represents the electromagnetic cavity, while ν is the outer unit normal to Ω and ε denotes the electric permittivity of the material medium filling the cavity Ω. The boundary condition $\nu \times u = 0$ on $\partial\Omega$ is used in the case the boundary models perfectly conducting walls.

It is not difficult to see that the spectrum of problem (1) is discrete, consisting of non-negative eigenvalues $\{\lambda_j\}_{n\in\mathbb{N}}$ of finite multiplicity which can be arranged in an increasing, divergent sequence

$$0 \leq \lambda_1 \leq \lambda_2 \leq \cdots \leq \lambda_n \leq \cdots \nearrow +\infty.$$

In this talk we present some results concerning the dependence of the eigenvalues λ with respect to the shape Ω of the cavity and the permittivity parameter ε. In particular, we provide Hadamard-type formulas for the derivatives of the eigenvalues as well as Rellich-Nagy-type theorems describing the bifurcation phenomena of multiple eigenvalues, and apply them to certain constrained optimization problems. We also discuss the spectral stability of problem (1) and give some hints on possible future works on these issues.

The results presented in the talk have been obtained in collaboration with Pier Domenico Lamberti [1, 2] and Paolo Luzzini [3].

References

[1] P.D. Lamberti, M. Zaccaron, *Shape sensitivity analysis for electromagnetic cavities*, Math. Methods Appl. Sci. 44, no. 13, pp. 10477–10500, 2021.

[2] P.D. Lamberti, M. Zaccaron, *Spectral stability of the* curl curl *operator via uniform Gaffney inequalities on perturbed electromagnetic cavities*, Mathematics in Engineering, 5(1), 2023.

[3] P. Luzzini, M. Zaccaron, *A few results on permittivity variations in electromagnetic cavities*, Submitted for publication.

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