



HAL
open science

Numerical inverse wave problems for quantitative viscoelastic reconstructions

Florian Faucher

► **To cite this version:**

Florian Faucher. Numerical inverse wave problems for quantitative viscoelastic reconstructions. Inverse Problems: Modeling and Simulation, The Eurasian Association on Inverse Problems, May 2024, Il-Mellieħa, Malta. hal-04854272

HAL Id: hal-04854272

<https://inria.hal.science/hal-04854272v1>

Submitted on 23 Dec 2024

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



Distributed under a Creative Commons Attribution 4.0 International License

Numerical inverse wave problems for quantitative viscoelastic reconstructions

Florian Faucher¹, Otmar Scherzer², Ha Pham¹, H el ene Barucq¹

¹) Team Makutu, Inria, Universit e de Pau et des Pays de l'Adour, TotalEnergies,
CNRS, France.

florian.faucher@inria.fr

²) Faculty of Mathematics, University of Vienna, Oskar-Morgenstern-Platz, Austria.

We consider the inverse problem for the quantitative reconstruction of the material properties that characterize a viscoelastic medium from wave measurements. Waves in such media display loss of energy (attenuation), and their propagation is mathematically modeled with linear viscoelastic equations, [1]. The time-harmonic formulation of the wave problem is considered to facilitate the investigation of the different attenuation models which are frequency-dependent. For the numerical discretization of the viscoelastic wave equations composed of the equation of motion and constitutive law, the hybridizable discontinuous Galerkin (HDG, [2]) method is employed and allows to reduce the computational cost. For the stabilization of HDG numerical traces, we further construct a hybridized Godunov-upwind flux for anisotropic elasticity, [3]. Then, the nonlinear inversion follows a minimization algorithm to iteratively update the elastic moduli. We carry out reconstructions with attenuation model uncertainty ([4]), that is, using different models of attenuation between the modeling and inversion. We illustrate with ultrasound imaging experiment of synthetic breast sample reconstruction.

References

- [1] J. M. Carcione, Wave fields in real media: Wave propagation in anisotropic, anelastic, porous and electromagnetic media, *Elsevier* (2007).
- [2] B. Cockburn, J. Gopalakrishnan and R. Lazarov, Unified hybridization of discontinuous Galerkin, mixed, and continuous Galerkin methods for second order elliptic problems, *SIAM Journal on Numerical Analysis* 47 (2009).
- [3] H. Pham, F. Faucher and H. Barucq, Numerical investigation of stabilization in the Hybridizable Discontinuous Galerkin method for linear anisotropic elastic equation, *arXiv preprint arXiv:2403.02862* (2024).
- [4] F. Faucher and O. Scherzer, Quantitative inverse problem in visco-acoustic media under attenuation model uncertainty, *Journal of Computational Physics* 472 (2023).