Data-driven characterization of viscoelastic materials using time-harmonic hydroacoustic measurements

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Abstract: Predictive numerical tools in computational mechanics require choosing an adequate model to capture the material's physical behaviour under consideration. The most common assumptions regarding linear wave propagation in a viscoelastic material are the standard linear solid model, (generalized) Maxwell, Kelvin-Voigt models [1] or the most recent fractional derivative models [2]. Usually, once the frequency-dependent constitutive law is fixed, the intrinsic parameters of the mathematical model are estimated to fit the available experimental data with the mechanical response of that model. This modelling methodology potentially suffers from the epistemic uncertainty of an inadequate a priori model selection. However, in this work, the mathematical modelling of linear viscoelastic materials and the choice of their frequency-dependent constitutive laws is performed based only on the available experimental measurements without imposing any functional frequency dependence [3]. This data-driven approach requires the numerical solution of an inverse problem for each frequency. The acoustic response of a viscoelastic material due to the time-harmonic excitations has been calculated numerically. In these numerical simulations, the transducer's non-planar directivity pattern has been considered. Experimental measurements of insertion loss and fractional power dissipation in underwater acoustics have been used to illustrate the data-driven methodology that avoids selecting a parametric viscoelastic model.

References:

[1] R.M. Christensen. Theory of Viscoelasticity (2nd edition), Dover civil and mechanical engineering, Dover Publications (2013).

[2] S.Y. Kim, D.H. Lee. Identification of fractional-derivative-model parameters of viscoelastic materials from measured FRFs. J. Sound Vib., 324 (2009), pp. 570-586, doi:10.1016/j.jsv.2009.02.040.

[3] L. Río-Martín, A. Prieto. Data-driven characterization of viscoelastic materials using time-harmonic hydroacoustic measurements, Comput. Struct., 292 (2024), pp. 107229, doi: 10.1016/j.compstruc.2023.107229.