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Numerical modeling for design of viscoelastic coatings with favorable sound absorbing properties

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Thin rubber layers with spherical cavities can be used to redistribute normally incident sonar energy in the transverse direction, where it suffers losses by anelastic absorption. This is the basis for an old German idea for anechoic submarine coatings. Here, numerical modeling of the anechoic effect is performed by adapting modern techniques for electron scattering and band gap computations for photonic and phononic crystals. Reflection and transmission matrices are computed recursively, from basic ones for layers containing periodic arrays of cavities. The shear and viscoelastic properties of the rubber matrix material turn out to be crucial. The reflectivity of the obtained structure (typically a coated steel plate surrounded by water) will depend in a nonlinear way on the geometry (for example cavity radii and spacing) and the material parameters. Two different techniques are used to design coatings with favorable sound absorbing properties. The first one is of theoretical interest, and it is based on the observation that the reflectivity is an analytic function of the shear wave velocity of the rubber. It follows that winding-number methods can be applied to design coatings with zero reflectivity at isolated frequencies. With appropriately implemented error control, the existence of a parameter choice providing zero reflectivity is actually proved. To achieve low reflectivity within a broad frequency band, however, different techniques are needed. Here, genetic algorithms are applied.