Multiscale modeling of acoustic shielding materials

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Enabling new technology

Background

High-tech systems must be protected from acoustic excitations while operating in a noisy environment. Acoustic foams can improve the performance depending on the interaction of the acoustic wave and the microstructure of the foam.

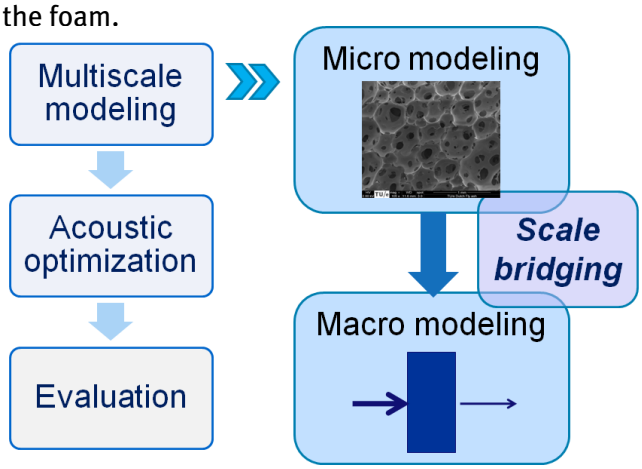

Figure 1: The plan of this project and the current work focusing on the scale bridging technique.

Approach

Macroscopic sound propagation in a porous medium can be described by Biot's isotropic poroelastic equations involving microstructure-dependent parameters. Starting from the microscopic governing equations of a representative volume element (RVE), these Biot's parameters can be obtained based on the homogenization approach as shown in Figure 2.

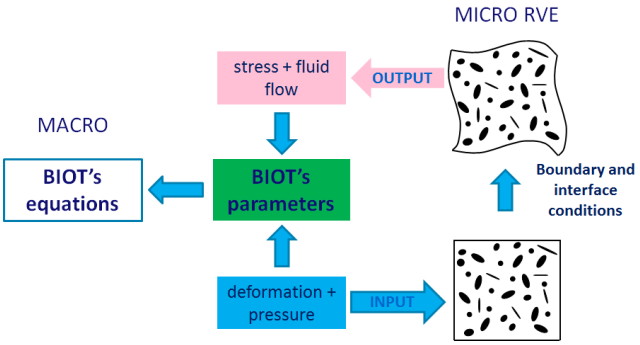

Figure 2: Homogenization approach to determine Biot's parameters.

Simulation

A 3D cubic is simulated with given macroscopic solid deformation and fluid pressure gradient. The output Biot's parameters are used in a macroscopic transmission loss simulation as shown in Figure 3.

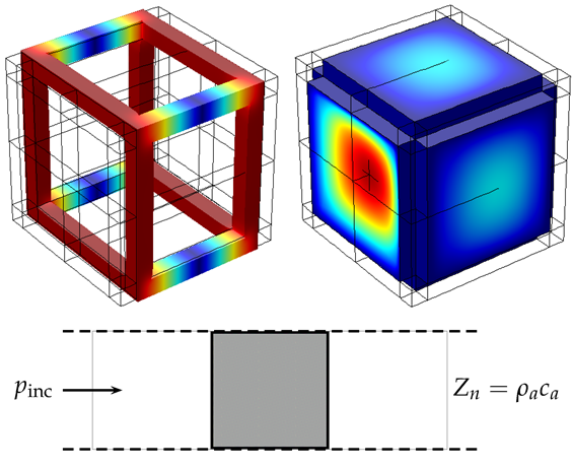

Figure 3: 3D cubic RVE with the deformable solid skeleton (the left graph) and the air (the right graph). The bottom graph illustrates the macroscopic transmission loss simulation.

The homogenization result is compared with a semi-phenomenological model. Besides, a direct numerical simulation (DNS) is used for reference. It shows that the performance of the homogenization approach is better.

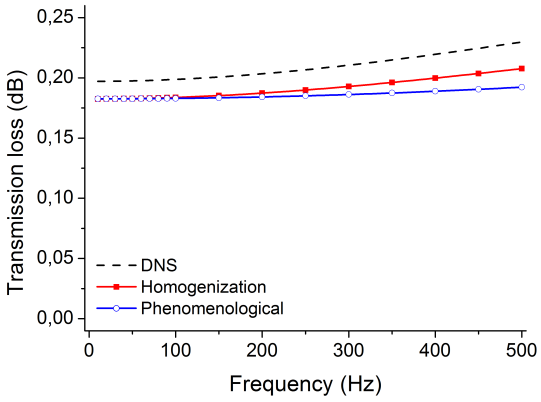

Figure 4: Comparison of transmission losses in different models.

Conclusions & future work

The homogenization approach gives a better performance for Biot's equations. Further work is to include microscopic thermal effects and consider realistic microstructures.