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# Multiscale modeling of acoustic shielding materials

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Enabling new technology

## Background

Acoustic shielding is very important for high-tech systems and in human life. Porous materials like acoustic foams can be used to improve the shielding performance and their absorption abilities depends on the interaction of the acoustic wave and the complex microstructure. These effects are captured in a multiscale model for the porous material.

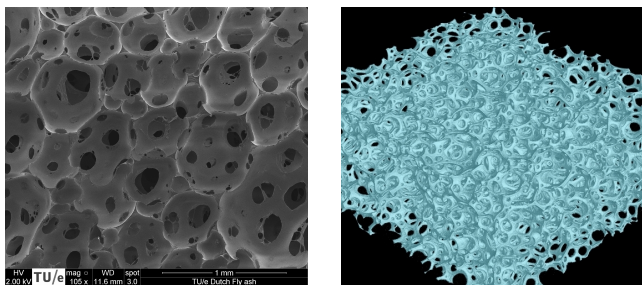


Figure 1: Microstructure of an acoustic foam obtained from scanning electron microscopy (left) and X-ray computed tomography (right).

## Framework

As illustrated in Figure 2, the macroscopic problem is described by the solid displacement  $u_M^s$  and the air pressure  $p_M^f$ . The associated macroscopic gradients are prescribed on the boundary of the linearized microscopic Representative Volume Element (RVE). The homogenized solid stress  $\sigma_M^s$  and air displacement  $u_M^f$  are calculated based on the energy consistency.

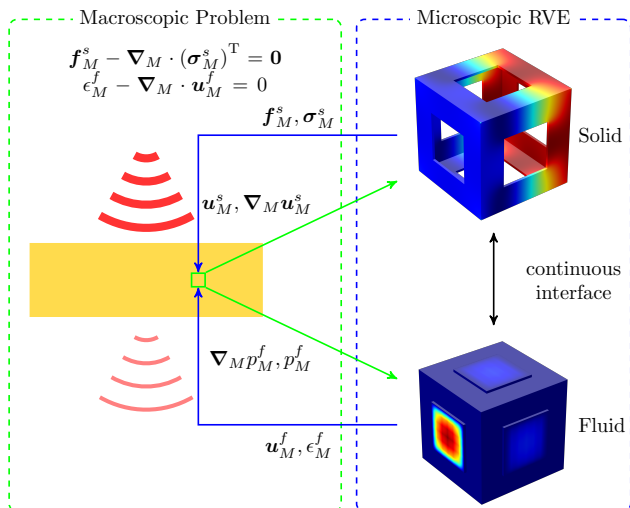


Figure 2: The homogenization framework of sound propagation in a deformable porous material.

## Simulation

A macroscopic sound absorption test on a porous layer is conducted as shown in Figure 3 and there are two models: (a) anisotropic Biot's equations with the parameters obtained from the homogenization approach and (b) modification fully based on the homogenization approach.

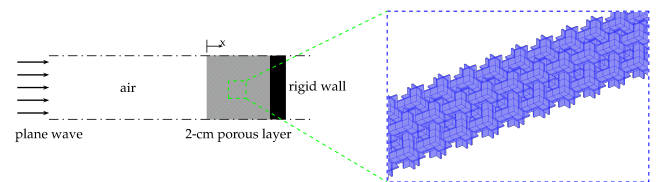


Figure 3: Sound absorption test of the porous material with the RVE in Figure 2.

The results is compared with a reference of direct numerical simulation (DNS). It can be found that the resonance frequency predicted by Biot's equations is higher than the DNS, whereas the modification gives a better result. The deviation at high frequency can be due to the intrinsic limitation of the homogenization approach because the wavelength becomes close to the characteristic pore size at high frequency so that the scale separation is not well satisfied.

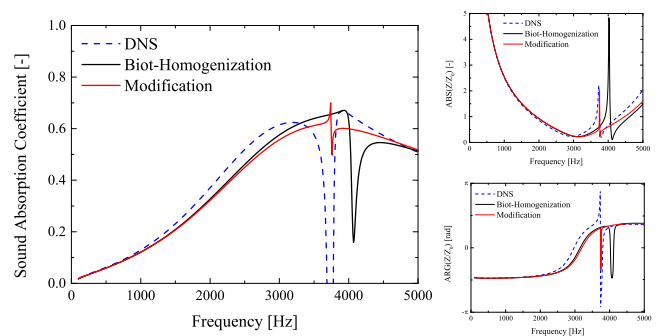


Figure 4: Comparisons of normal incident sound absorption coefficients (left figure) and the surface impedances (right figures).

## Conclusions & future work

The homogenization framework gives a good description of the sound propagation problem in the porous material. The next step is to consider realistic microstructure based on the X-ray computed tomography technique.