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Multiscale reduced-order model for metafoams

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Current soundproofing materials are crucial for mitigating noise in the automotive, aeronautical and building industries mostly because they have remarkable performance at the mid- and high-audible frequencies. To obtain materials that also span the low-audible frequency range, a metafoam concept has recently been proposed in [1]. The metafoam is a foam-like structure with embedded small particles within its pores resulting in a mass-spring effect that creates tunable bandgaps to target frequencies in the same fashion as the locally resonant acoustic metamaterials (LRAMs). However, wave propagation modeling in poroelastic materials poses computational challenges because of fine-scale processes at the pore level, such as air-solid drag forces, interacting with large-scale acoustic waves in the so-called subwavelength regime. In general, intrinsically multiscale problems become rapidly infeasible to solve due to limited computational resources, urging for reduced-order models to overcome the computational cost and speed up the material development based on their microstructure design.

In this contribution, a transient computational homogenization framework is proposed for describing the dynamic macroscopic response of poroelastic materials with locally resonant components at the microscopic level. Extending the approach proposed in [2], the model is capable of capturing emerging exotic characteristics such as bandgaps as well as the macroscopic Biot-like behavior of regular acoustic foams. Numerical examples demonstrate the efficiency and suitability of the proposed multiscale approach to model problems with more application-oriented features.

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