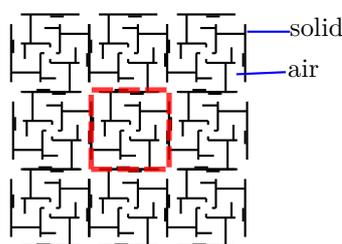


Master Thesis

## Design of double-negative acoustic metamaterials using genetic algorithms

Acoustic metamaterials (AMM) are artificially created materials, which are able to manipulate acoustic waves in a way that is unreachable with purely natural materials. Usually, an AMM is realized as an array of heterogeneous cells (air-solid or solid-solid) and it can be manufactured by 3D-printing, molding, lithography or laser cutting. One promising application of AMM is superlensing, which is the ability to focus acoustic beams better than the diffraction limit predicts and it is a basis for improved resolution for ultrasound imaging. Superlensing can be realized for a double-negative AMM, i.e. an AMM with negative effective density and negative effective bulk modulus. The design of such an AMM is still a challenging problem due to its non-convexity and ill-conditioning. One approach for the design of AMM is a combination of topology optimization with genetic algorithms (GA). Topology optimization does not restrict the heterogeneous geometry of the periodic cell of the AMM. A properly selected fitness function in GA pushes the evolution of the population toward double-negativity.

The aim of the thesis is implementation of genetic algorithms for the design of double-negative acoustic metamaterials in MATLAB. The focus lies on studying the influence of mesh size, fitness function and options of the genetic algorithm on the quality of the design.



Solid-air periodic acoustic metamaterial.

### The specific tasks are

- Study of literature
- Implementation of the equation of motion for 2D acoustic metamaterial in MATLAB
- Computation of effective bulk modulus and effective density
- Formulation of an optimization problem and application of a genetic algorithm to it
- Testing and studying the influence of mesh size, fitness function and options of the genetic algorithm on the quality of the design
- Interpretation and documenting of results

### Areas of interest

Acoustic metamaterials, Genetic algorithms, Topology optimization, MATLAB

### Literature

Dong, H. W. et. al: *Systematic design and realization of double-negative acoustic metamaterials by topology optimization*. In: Acta Materialia 172 (2019), pp. 102-120.