PhD proposal

Acceptance by end of June 2019
Starting date 1st October 2019 or later

Dynamical study of mechanical metamaterials for ultrasonics

Thesis directors

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LABORATORY / place of work

FEMTO-ST Institute, Université de Franche-Comté, CNRS, ENSMM, UTBM
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PHD Description

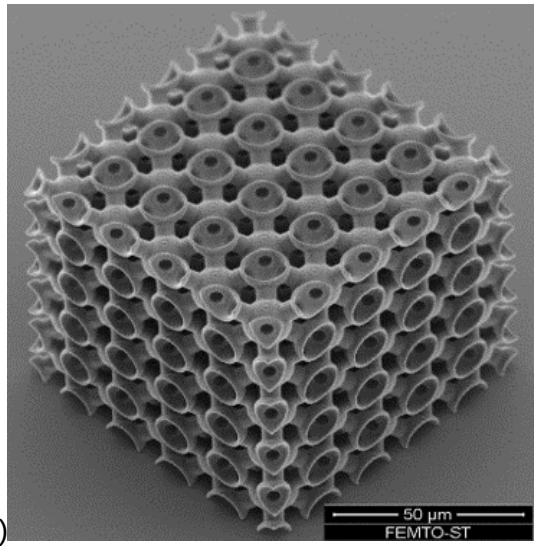
The goal of the thesis will be to go beyond the state of the art by manufacturing 3D mechanical metamaterials and measuring their "meta" properties in the dynamic and nonlinear regime, typically in the MHz range. Potential long term applications are, for example, the design of ultrasonic transducers suitable for radiation in water (impedance matching / beamforming) or for cranial box imaging (acoustic wave coupling in the skull then the brain, directionality and focus). The project will combine the unique expertise of the FEMTO-ST Phononics and Microscopy group in characterization, fabrication, modelling and design.

Manufacturing will be performed by additive manufacturing, either by 3D printing or by direct laser writing by two-photon photopolymerization, depending on the target frequency range. Figure 1a shows an example of a periodic 3D metamaterial made using the Nanoscribe equipment of the FEMTO-ST laboratory.

The behaviour of the phononic structures will be characterized by using a MEMS analyzer (Figure 1b) and by ultrasonic measurements to determine acoustic velocities as a function of the direction of propagation. The design will be based on the analysis of the homogenized properties of metamaterials and on the technique of space transformation. Modelling will be carried out by finite element analysis of the properties of a unit cell or a complete structure.

We expect a complete thesis work, which includes the design and the characterization of meta-structures. The complete measurement of effective anisotropic velocities in the MHz regime according to the space symmetry of the structures would be a first, as well as the development of the concept of effective impedance for coupling of waves at a solid-liquid interface and its tuning over a broad spectral range.

Keywords: wave physics, acoustic metamaterials, phononic crystals.

(a) 

(b) 

Figure 1 : (a) 3D Metamaterial fabricated with the Nanoscribe @ FEMTO-ST (b) MEMS analyser.

Resources

Manufacturing: DLW (direct laser writing) Nanoscribe, 3D resin printer, available in the laboratory.
Characterization: MEMS analyser and probes for immersed ultrasonic measurements will be used for the characterization of vibrations.
Modelling: Computation machines and software (Comsol, freefem++) available in the group.

Group

FEMTO-ST is a joint research unit of the National Scientific Research Center (CNRS) and of the Université de Bourgogne Franche-Comté (https://www.femto-st.fr/fr). The doctoral work will be carried out in the Phononics and microscopy research group (http://teams.femto-st.fr/phononics-microscopy/fr). The supervisors are active in the fields of phononic crystals and metamaterials. For more information on the supervisors please refer to their homepages: http://members.femto-st.fr/muamer-kadic/ and http://members.femto-st.fr/vincent-laude/.

Candidate's profile

Scientific master degree in physics or engineering. Pronounced taste for wave physics. Good level in English. Writing skills (for scientific articles). Attractiveness toward the academic world. Computer skills required (for example: matlab / python / C ++ / etc.). Knowledge of finite element analysis appreciated. Experience in instrumentation and scientific computing would be a plus.
Thesis duration: 3 years
Financial support: Doctoral contract signed with the Univ. de Bourgogne Franche-Comté. Net salary approx. 1420€ / month.

How to Apply

Contact the supervisors by sending CV, cover letter, transcripts and classifications (at least for the two years of the master degree). If your resume is retained, you will be contacted quickly and an interview will be scheduled. During the interview, we may ask you to explain the contents of a scientific article that we will communicate beforehand.