Micro-macro homogenization of mechanical parameters of porous material

A three year joint PhD position between Le Mans University and KULeuven is available at LAUM, UMR 6613 CNRS in the field of numerical micro-macro homogenization of poroelastic materials,

Expected starting date: November 1st 2024
Application Deadline: October 1st 2024
Salary: Gross Salary of 2812 € (about 2250 € net) + Mobility allowance: 600 € gross + Family allowance depending of the status: 660 € gross
Working hours: 35h per week
Working time: 100% on the project

Project:
This doctoral project is part of a larger, multidisciplinary and international project VAMOR: “Vibro-Acoustic Model Order Reduction” (no. 101119903) funded under the Marie-Sklodowska-Curie Actions Doctoral Networks within the Horizon Europe Programme of the European Commission.
VAMOR contributes to a more sustainable and quieter future for Europe. Noise pollution has arisen as one of the key factors towards the degradation of the quality of life in European societies. Adding noise treatments commonly leads to an increase in mass and/or volume usage, harming the sustainability of the respective products, e.g. leading to heavier vehicles. To avoid such solutions and striving for the sustainability and optimal acoustic behavior of products, vibro-acoustic design needs to be pushed earlier in their design phase. Additionally, product sustainability can be also enhanced by exploiting the information included in sound waves emitted during their operation, detecting potential malfunctions. In that context, efficient physics-based sound modeling is a key enabler towards not only optimized and sustainable acoustic profiles through efficient design procedures, but also affordable so-called digital twins that monitor product performance in real time. To this end, the overarching goal of VAMOR is to provide high level scientific and transferable skills training on a new generation of efficient vibro-acoustic modeling techniques, so-called model order reduction (MOR) strategies, to a group of high achieving, competent doctoral candidates to promote a quieter and more sustainable environment.
VAMOR brings together a remarkable consortium, which combines research leading academic institutions - KU Leuven, Technische Universitaet Munchen (TUM), Technical University of Denmark (DTU), Kungliga Tekniska Hoegskolan (KTH), Universite du Mans, Conservatoire National des Arts et Metiers (CNAM) - with a constantly innovating, wide variety of industrial partners working on software, material, testing, design and sound enhancement (Siemens Industry Software NV, Müller BBM, Trèves, Phononic Vibes, Saint-Gobain Ecophon, Tyréns, Purifi ApS). By deploying such an inter-sectorial, multi-disciplinary consortium, VAMOR guarantees the creation of a coordinated research environment to develop and exploit novel tools for the efficient simulation of noise and vibration and promote sustainability and acoustic comfort of products.

Your tasks:
As doctoral candidate within this project you will work on the numerical modeling, design, manufacturing, and experimental validation of poroelastic materials. To do this :

- You investigate different modeling and model reduction strategies
- You investigate potential optimization strategies
- You design and measure prototypes to validate the models
- You identify the ideal solution for specific problems.

Profile:
If you recognize yourself in the story below, then you have the profile that fits the project and the research group:

- I have a master degree in acoustic, physics, mechanical engineering or mathematics.
- I am proficient in written and spoken English.
- **I have not had residence or main activities in France for more than 12 months in the last 3 years.**
- During my courses or prior professional activities, I have gathered some experience with at least one of the following: principles of acoustics, numerical modeling techniques, or experimental methods in acoustics. I have a profound interest for these topics.
- As a researcher I perform research in a structured and scientifically sound manner. I read technical papers, understand the nuances between different theories and implement and improve methodologies myself.
- In frequent reporting, varying between weekly to monthly, I show the results that I have obtained and I give a well-founded interpretation of those results. I iterate on my work and my approach based on the feedback of my supervisors which steer the direction of my research.
- It is important for me to work as an active team member and I am eager to share my results to in-spire and being inspired by my colleagues.
- During my PhD, I want to grow towards following up the project that I am involved in and representing the research group on project meetings and conferences. I see these events as an occasion to disseminate my work to an audience of international experts and research colleagues, and to learn about the larger context of my research and the research project.

Offer:
We offer a fully funded 3-year PhD position at LAUM, UMR 6613 CNRS. This is a joint degree with KULeuven. Poroelastic materials are used to mitigate both the acoustic and the elastic energies. This energy dissipation relies on visco-thermal and viscoelastic losses, which are inherent to the materials properties of the fluid and solid phases and to their microstructure. Relating the microstucture to the macroscopic behavior of poroelastic materials is therefore of primary importance to

design poroelastic materials. Two-scale homogenization [1,2,3] has been widely used to derive effective properties of such bi-phasic materials, principally when the skeleton is rigid [4,5]. The present thesis aims at developing and promoting the two-scale homogenization of the entire poroelastic materials, that is to derive the effective properties of both the fluid and the solid phases from the microgeometry. This microgeometry will then be optimized, graded, or designed to exhibited new behavior in poroelastic materials [6]. In that context, the candidate will use two-level model reduction techniques to reduce expensive numerical models. The first part of the work will consist in realizing a reduced model of an elementary cell by a condensation technique. This reduction will be done on the elementary beams of the elementary cell. A dispersion study will then be carried out to obtain the fundamental solutions (quasi-plane waves) propagating in the structure. An experimental validation phase, using existing test benches, will then be conducted on structures obtained by 3D printing. The second part will aim at setting up a reduced model for an assembly of many reduced elementary cells. Particularly Krylov recycling techniques will be considered. A dispersion study on the assembled structure will show if the reduced model modifies or not the wave properties of the material.

[1] J.-L. Auriault, C. Boutin, and C. Geindreau, Homogenization of Coupled Phenomena in Heterogenous Media (ISTE; J. Wiley, 2009).
[2 E. Sanchez-Palencia, Non-homogeneous media and vibration theory, Lecture notes in physics (Springer, 1980), Vol. 127, OCLC: 6447016.
[3] A. Bensoussan, J.-L. Lions, and G. Papanicolaou, Asymptotic Analysis of Periodic Structures (North-Holland Publishing Company, 1978), Vol. 5
[4] C. Perrot, F Chevillotte, and R. Panneton, Bottom-up approach for microstructure optimization of sound absorbing materials, *J. Acoust. Soc. Am.* 124, 940–948, 2008.
[5] J. Boulvert, T. Cavalieri, J. Costa-Baptista, L. Schwan, V. Romero-García, G. Gabard, E. R. Fotsing, A. Ross, J. Mardjono, and J.-P. Groby, Optimally graded porous material for broadband perfect absorption of sound, J. Appl. Phys. 126, 175101, 2019.
[6] T. Frenzel, M. Kadic, and M. Wegener, Three-dimensional mechanical metamaterials with a twist, Science 358, 1072-1074, 2017.

For further information about the position please contact Olivier Dazel (Olivier.Dazel@univ-lemans.fr), Mathieu Gaborit (Mathieu.Gaborit@univ-lemans.fr), Jean-Philippe Groby (Jean-Philippe.Groby@univ-lemans.fr), or Elke Deckers (elke.deckers@kuleuven.be)

We look forward to receiving your online application including a letter of motivation, CV, diplomas with transcripts and contact details of two referees. The PhD candidate will be selected in two stages: application file evaluation and at least 2 interviews.

Please also send your application to Jean-Philippe.Groby@univ-lemans.fr