Interfacing of efficiently partitioned problems involving multiple reduced-order model techniques

A four-year joint PhD position between Le Mans University and KTH Royal Institute of Technology is available in the field of numerical analysis for vibroacoustic problems using model order reduction problems,

Expected starting date: October 1st 2024
Application Deadline: July 1st 2024
Salary:
Salary complying with the KTH Doctoral student salary agreement, which includes the compensation provision by the EU consisting of a living allowance, a mobility allowance, and possibly a family allowance.
Working time: Full-time position, 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), The Royal Institute of Technology (KTH), Université 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.

Laboratoire d'Acoustique Le Mans Université · CNRS · UMR 6613

Your tasks:

As doctoral candidate within this project you will work on developping numerical schemes to model periodic vibroacoustic systems efficiently as well as validating the results numerically or experimentally. To do this:

- You investigate different modeling and model reduction strategies
- You investigate meta-modelling/surrogating strategies
- You identify and design/produce pertinent validation configurations
- You assess the efficacy of the proposed method and its range of applicability

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's degree in acoustics, physics, mechanical engineering or mathematics.
- I am proficient in written and spoken English.
- **I have not had residence or main activities in Sweden for more than 12 months over 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, meta-modelling strategies. 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, 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 inspire 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 4-year PhD position at KTH Royal Institute of Technology, Stockholm. This is a joint degree with LAUM UMR CNRS 6613, Le Mans, France.

Microstructured materials and metamaterials with complex inner motions are often challenging to represent and particularly so when the design space of the unit cell comprises numerous dimensions. The target of the present PhD project is to explore the use of domain decomposition techniques to represent parts of the unit cell of a vibroacoustic metamaterial as well as meta-modelling strategies at the pre-resolution level to avoid large parameter sweeps while capturing the responses over the entire design space with sufficient fidelity.

In recent years, metamaterials based on Distorted Kelvin Cells (DKC) [1,2] have been under investigation by an international team involving, among others, KTH and the LAUM. These materials present a high-dimensionality design space and exhibit a large variety of behaviour most of which haven't been explored at the present. In prior efforts, a link between the microstructure and specific mechanical, vibroacoustic or acoustic behaviour was described [3,4] but the current explorations are limited by the computational cost of sweeping such a large design space. The proposed project focuses on computational aspects and on partitioning the material and/or the unit cell to propose faster resolution time with satisfying precision. To explore the design space, the proposed option is to rely on interpolating the numerical models before resolution, trying to leverage condensation and meta-modelling strategies to decompose the unit cell or groups of unit cells into numerical building blocks that can be parametrized and combined at will at little to no computational cost. In order to assess the validity of the proposed models, the candidate will set up pertinent validation cases either numerical or experimental at the macro and micro-structure levels.

[1] Mao, H. *et al.* Twist, tilt and stretch: From isometric Kelvin cells to anisotropic cellular materials. *Materials & Design* **193**, 108855 (2020).
[2] Mao, H., Rumpler, R. & Göransson, P. An inverse method for characterisation of the static elastic Hooke's tensors of solid frame of anisotropic open-cell materials. *International Journal of Engineering Science* **147**, 103198 (2020).
[3] Mao, H. *et al.* Dynamic behaviour of low- to high-density anisotropic cellular materials. *Journal of Sound and Vibration* **536**, 117137 (2022).
[4] Gaborit, M., Mao, H., Rumpler, R. & Göransson, P. Towards fully controlled anisotropy in cellular porous media: an overview. *inter noise* **263**, 5253–5259 (2021).

For further information about the position please contact Mathieu Gaborit (Mathieu.Gaborit@univ-lemans.fr), Olivier Dazel (Olivier.Dazel@univ-lemans.fr), Jean-Philippe Groby (Jean-Philippe.Groby@univ-lemans.fr), Romain Rumpler (rumpler@kth.se) or Huina Mao (huina@kth.se)

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.

Application must be made online via the KTH Royal Institute of Technology recruitment portal : https://www.kth.se/lediga-jobb/732135?l=en .