

---

# A PINN-based domain decomposition method for the optimal design of additively manufactured lattice structures

Thomas Cadart<sup>\*1</sup>, Thibaut Hirschler<sup>2</sup>, Sébastien Roth<sup>1</sup>, Frédéric Demoly<sup>1,3</sup>, Slim Bahi<sup>4</sup>,  
and Nadhir Lebaal<sup>1</sup>

<sup>1</sup>Laboratoire Interdisciplinaire Carnot de Bourgogne – Université de Technologie de Belfort-Montbéliard, Université de Bourgogne, Université Bourgogne Franche-Comté [COMUE], Centre National de la Recherche Scientifique – France

<sup>2</sup>Laboratoire Interdisciplinaire Carnot de Bourgogne – Université de Technologie de Belfort-Montbéliard, Université de Bourgogne, Université Bourgogne Franche-Comté [COMUE], Centre National de la Recherche Scientifique – France

<sup>3</sup>Institut Universitaire de France (IUF) – Ministère de l'éducation nationale, de l'Enseignement supérieur et de la Recherche, Ministère de l'éducation nationale, de l'Enseignement supérieur et de la Recherche, Ministère de l'éducation nationale, de l'Enseignement supérieur et de la Recherche, Ministère de l'éducation nationale, de l'Enseignement supérieur et de la Recherche, Ministère de l'éducation nationale, de l'Enseignement supérieur et de la Recherche, Ministère de l'Education nationale, de l'Enseignement supérieur et de la Recherche, Ministère de l'Education nationale, de l'Enseignement supérieur et de la Recherche – Maison des Universités 103 Boulevard Saint-Michel 75005 Paris, France

<sup>4</sup>Laboratoire d'Etude des Microstructures et de Mécanique des Matériaux (LEM3) – Université de Lorraine, Centre National de la Recherche Scientifique, Arts et Métiers Sciences et Technologies, Centre National de la Recherche Scientifique : UMR7239 – F-57070 Metz, France

## Abstract

While the rise of additive manufacturing techniques has made it easier to produce complex lattice structures, optimizing their designs for specific applications remains challenging, and requires advanced numerical simulations. Homogenization-based multiscale methods struggle with insufficient scale separation, while directly applying standard numerical methods to the full fine-scale problem is often computationally intensive. Design optimization exacerbates the computational challenge, as it involves numerous successive simulations to enhance the structures effectively. Recent research aims to address this challenge by employing multiscale topology optimization, although the persistent issue of scale separation still limits its effectiveness. Alternatively, a new class of approaches has emerged which combine domain decomposition methods together with pre-train models.

In this context, we develop a Physics-Informed Neural Network (PINN) based domain decomposition method. We straightforwardly decompose the lattice into unit cells and employ a primal domain decomposition approach which consists in solving interface problems where only the displacements at the cell connections are involved: a technique known as Balanced Domain Decomposition (BDD). To efficiently handle the local sub-problems to be solved,

---

<sup>\*</sup>Speaker

we constructed a PINN that learned the relationship between boundary displacements and reaction forces of shape-parameterized unit cells. By leveraging the pre-trained PINN within our domain decomposition framework, we not only obtain a fast solver, but also a fast optimization procedure as the relationships between the unit cell geometry and its mechanical behavior have been explicitly discovered during the training phase. During the talk, we will illustrate how this approach facilitates the optimal design of additively manufactured lattice structures for specific applications.