FOR APPLICATION, PLEASE CONTACT ADVISOR(S) BY EMAIL WITH COPY TO:
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Research Topic for the ParisTech/CSC PhD Program

Field: Materials Science, Mechanics, Fluids

Subfield: Mechanical engineering, Computational mechanics, Engineering design

Title: Computational design and optimization of architectured materials

ParisTech School: Arts et Métiers, Paris campus

Advisor(s) Name: Dr. Justin DIRRENBERGER
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Short description of possible research topics for a PhD: Architectured materials are an emerging class of advanced materials that bring new possibilities in terms of functional and structural properties. Their improved specific properties are due to a thoughtful topological design. In the context of a project aiming at developing additive manufacturing for architectured materials, we intend to investigate lightweight materials with the ability to deform with a large amplitude in the elastic domain. The goal of the present project is to perform a parametric study for optimizing the effective (homogenized) behaviour of an auxetic (negative Poisson's ratio) periodic cell, obtained through additive manufacturing (AM), which is also well-studied in the literature, and seems a rather good candidate regarding the set of requirements defined, e.g. crashworthiness, acoustic damping, actuation (cf. Fig.1). Various geometric parameters will be considered in this computational experiment study, using FEA. Effective properties for each configuration will be obtained through computational homogenization. A finite deformation anisotropic thermo-elastoplastic framework will be adopted in order to account for material and geometric non-linearities.

Fig.1: auxetic actuated wingbox (left) and AM optimized parts (Airbus, right)

Required background of the student: computational mechanics, engineering, materials science, metallurgy, applied mathematics, physics, or any other relevant field.

A list of 5(max.) representative publications of the group:

- Wang, Z. P., Poh, L. H., Dirrenberger, J., Zhu, Y., & Forest, S. (2017). Isogeometric shape optimization of smoothed petal auxetic structures via computational periodic homogenization. Computer Methods in Applied Mechanics and Engineering, 323, 250-271.
- Auffray, N., Dirrenberger, J., & Rosi, G. (2015). A complete description of bi-dimensional anisotropic strain-gradient elasticity. International Journal of Solids and Structures, 69, 195-206.
- Dirrenberger, J., Forest, S., & Jeulin, D. (2013). Effective elastic properties of auxetic microstructures: anisotropy and structural applications. Int. Journal of Mechanics and Materials in Design, 9(1), 21-33.
- Dirrenberger, J., Forest, S., & Jeulin, D. (2012). Elastoplasticity of auxetic materials. Computational Materials Science, 64, 57-61.
- Dirrenberger, J., Forest, S., Jeulin, D., & Colin, C. (2011). Homogenization of periodic auxetic materials. Procedia Engineering, 10, 1847-1852.