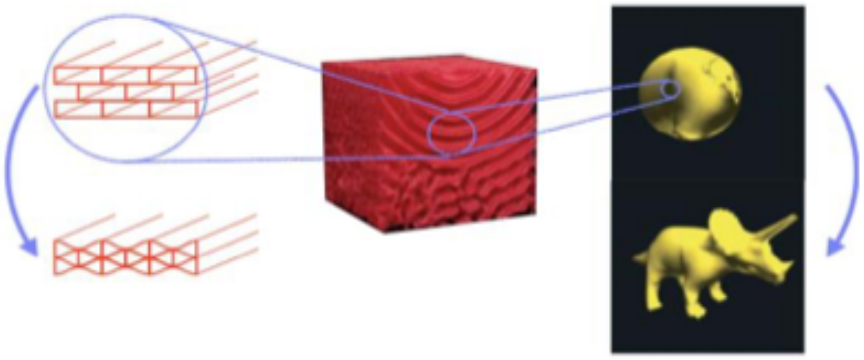
De-Pressurization Driven Programmable Materials

PhD funding

Lab. **PMMH** (Paris) + **LJK** (Grenoble) + **LORIA** (Nancy) in FRANCE

Architected materials, capable of changing shape in response to an external stimulus, open up new perspectives (in soft robotics, medicine, and frugal digital technologies) and are the subject of highly active research. We propose a novel approach: designing solid cellular materials (3D-printed) whose shape and mechanical properties evolve in a controlled manner when subject to internal depressurization.



This depressurization-based actuation is a promising new concept, enabling large-amplitude reversible deformations and raising new fundamental questions. Another original aspect of the project is its **interdisciplinarity**: collaboration in **Mechanics-Physics** (experiments at PMMH) and **Computer Graphics** (inverse problems at LJK and printability at LORIA). These disciplines have only recently discovered shared interests and have had limited interaction, so combining their separately developed tools could lead to significant breakthroughs.

In this CNRS-funded PhD thesis, we aim to develop a programmable material-machine capable of deforming into a target geometry upon depressurization. We will seek to determine the internal architecture of anisotropic cellular patterns (lamellae, tubes, staggered arrangements, etc.), optimize their printability and mechanical characteristics, and then determine the required deformation distribution to achieve complex shapes (inverse problem). Finally, we will work to automatically generate printable internal architectures and experimentally test these new shape-changing materials (3D scanning, stiffness).

Desired Profile: MSc (or equivalent) in Physics, Mechanics, or Computer Graphics.
Interest in experimentation (mechanical-physics, 3D printing) and/or programming and numerical methods (optimization, simulation, etc.). In this interdisciplinary work, the balance between disciplines can be adjusted, but the project will draw on the expertise of all three laboratories (where research stays are planned), thus opening up a new interdisciplinary field.

Contact :

PMMH (ESPCI hosted on Campus Jussieu, Paris 5th)
Benoît Roman benoit.roman@espci.fr blog.espci.fr/benoitroman, José Bico, jose.bico@espci.fr blog.espci.fr/jbico Etienne Reyssat etienne.reyssat@espci.fr

LJK (Genoble) - team CRAFT
Mélina Skouras, melina.skouras@inria.fr,
https://imagine.inrialpes.fr/people/mskouras/index.htm
Georges-Pierre Bonneau, georges-pierre.bonneau@inria.fr,
https://team.inria.fr/craft/georges-pierre-bonneau/

LORIA (Nancy) - team MFX
Camille Schreck, camille.schreck@inria.fr schreckc.github.io
Sylvain Lefebvre, sylvain.lefebvre@inria.fr antexel.com/sylefeb/research/