

INTERNSHIP-PhD PROPOSAL

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Internship location: ENS de Lyon

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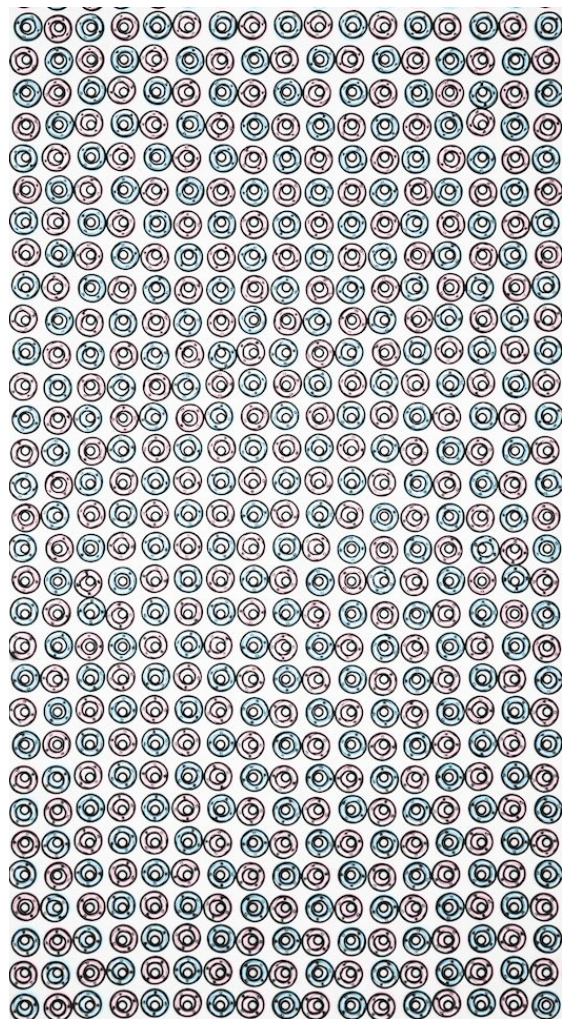
Active MetaMachines

When humans learned to weave, they created an early form of mechanical metamaterial: a repeating arrangement of threads whose architecture shapes how the fabric deforms. What if the elementary units could themselves generate motion?

This idea motivates active metamachines: assemblies in which each building block is a miniature machine. Through interactions with their neighbours, these units can coordinate their dynamics, opening a route to structures that deform or move coherently without programming every individual component. Our recent experiments have demonstrated how thousands of microscopic rotary motors spontaneously develop coherent collective dynamics in planar arrays [1].

This experimental project will build on these results to create autonomous metamachines whose units are arranged and coupled in three dimensions. Combining 3D nanoprinting with techniques for powering colloidal matter, we will fabricate networks of interacting microscopic machines and investigate their collective dynamics. We aim to understand how their architecture controls synchronization, and whether local interactions can generate coordinated deformation or locomotion of the whole structure.

The work will combine 3D printing and microfluidic experiments with statistical data analysis to connect the motion of individual units to the dynamics of the assembly. Depending on your interests and skills, it can also include theoretical modelling and numerical simulations.



Close view of a Metamachine made of thousands of interacting rotary motors [1].
Rotor diameter ~80 microns

[1] Phase coherence and disorder-induced wave propagation in micromotor arrays

Romane Braun, Alexis Poncet, Alexandre Morin and Denis Bartolo, *Nature Physics*, (2026) [[pdf](#)]