

Internship

Active Flow Networks

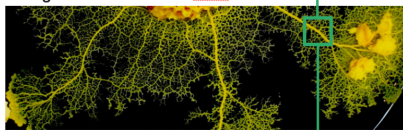
Context. How do biological organisms know how to transport matter and information exactly where they are needed? Many, like the slime mold rely on active flow networks. These systems are governed by the principles of active matter, in which the medium is set in motion locally—through contractions or chemical activity. Remarkably, these local flows self-organize into transport that reaches the right place at the right time. While these highly effective transport networks are widely observed across nature, the physical mechanisms that allow them to self-organize and direct flows remain poorly understood. In this internship, we will design and study a novel artificial system to recreate these active flow networks and uncover the physical rules governing them.

The study will be part of the ongoing ERC Starting Grant project (Self-Flow) that is aiming at bridging the gap between living and artificial matter [1,2,3]. This internship will experimentally recreate active flow in channel networks and model how such flow leads to self-organized functional transport. The student will work together with PhD students and postdocs and use experimental facilities to characterize the flow rate and pressure gradient produced by active pumps. Working with cutting-edge Electrohydrodynamic (EHD) pumping, the student will gain practical experience using our microcontroller-based (Arduino) setup to map how flow and pressure gradients adapt to varying channel configurations. These results will cast new light on active transport in vessel networks. By recreating active transport in artificial networks, the results will also open the way to innovative solutions for adaptive cooling and water management technologies in networks that can easily be disassembled and reused. **The internship can be followed by a PhD grant.**

Active mechanics

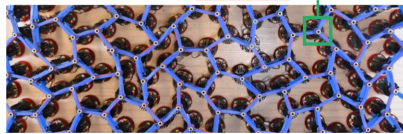
Functionalities emerge from **distributed active forces**

Living matter - The slime mold



CNRS News

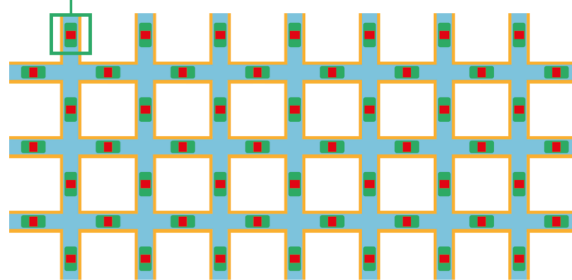
Active materials - robotic metamaterial



M. Brandenbourger, et al, (2023) arXiv:2108.08837.

Self-contracting vascular networks

Understand and recreate living matter functionalities emerging from **distributed self-contractions**



● Fluid ● Vessel ■ Self-contracting actuator

Figure 1 (Left) Two examples of systems described by active mechanics, a slime mold and a robotic material. (Right) Schematic of an artificial self-contracting network.

Duration: 5-6 months

Grant: 600 euros per month

Degree: M2, Starting from February 2027.

Location: IRPHE, 49 Rue F. Joliot Curie 13013 Marseille

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References:

- [1] Veenstra, J., Scheibner, C., Brandenbourger, M., Binysh, J., Souslov, A., Vitelli, V., & Coulaïs, C. (2025). Adaptive locomotion of active solids. *Nature*, 639(8056), 935-941.
- [2] Winn, A., Parmentier, J., Katifori, E., Brandenbourger, M. (2026) Unidirectional flow from continuous broken symmetries. *PNAS*
- [3] Garcia, R. F. Q., Antunes, G. C., Harting, J., Stark, H., Valeriani, C., Brandenbourger, M., ... & Ruiz-Garcia, M. (2025). Spontaneous emergence of solitary waves in active flow networks. *arXiv preprint arXiv:2511.13448*.