

# ParisTech

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École des Ponts  
ParisTech



## RESEARCH TOPIC FOR THE PARISTECH/CSC PHD PROGRAM (one page maximum)

**Field:** Physics, Optics

**Subfield:** (Mech. Eng / Computer Science)

**Title:** Morphological Swarm Robotics

**ParisTech School:** ESPCI Paris | PSL

**Advisor(s) Name:** Olivier Dauchot

**Advisor(s) Email:** [olivier.dauchot@espci.fr](mailto:olivier.dauchot@espci.fr)

**Research group/Lab:** Gulliver Lab

**Lab location:** Paris

**(Lab/Advisor website):** [www.gulliver.espci.fr](http://www.gulliver.espci.fr)

**Short description of possible research topics for a PhD:** (10-15 lines in English + optional figure)

In this project, we are interested in swarm robotics, where a large number of robots with limited computation and communication power are considered. Our goal is to propose new design methods, with a particular focus on collective decision making using both morphological and logical computation.

To do so, we aim at new kind of swarm bots, where the shape factor guarantees the group dynamics, while each robot embeds a lightweight system-on-chip, sensors and actuators that can be used to modulate the robot behaviors on-the-fly.

We will then look for specific educated collective behaviors: starting from the spontaneous phase obtained from the purely physical interactions of our robots we aim at applying minimal control from embodied capabilities on each bot, to induce specific collective behavior, which we will refer to as operational phases. Optimizing such behavior, we will aim at the realization of complex collective tasks.

**Required background of the student:** (What should be the main field of study of the applicant before applying?)

Our approach towards this topic is definitely the one of physicists; it is therefore important to have a good background in physics. At the same time, the object of studies, the robot swarm, requires a good knowledge of Fablab tools, such as 3D printers, laser cutter, electronics, which is closer to mechanical engineering. Finally being familiar with computer sciences, sensor-controllers is important too.

**A list of 5 (max.) representative publications of the group:** (Related to the research topic)

This is a new topic of the group. Before the group was focusing on physical active matter (not involving robots). This is why in the five publication below, only one is directly related to robotics.

1. *Distributed On-line Learning in Swarm Robotics with Limited Communication Bandwidth*. Nicolas Fontbonne, Olivier Dauchot and Nicolas Bredeche. Proceedings of the IEEE Congress on Evolutionary Computation (CEC), 2020
2. *Dynamics of a Self-Propelled Particle in a Harmonic Trap*. O. Dauchot, and V. Démery. Phys. Rev. Lett. **122**, 068002 (2019).
3. *Spontaneously Flowing Crystal of Self-Propelled Particles*. G. Briand, M. Schindler and O. Dauchot. Phys. Rev. Lett **120**, 208001 (2018).
4. *Active versus Passive Hard Disks against a Membrane: Mechanical Pressure and Instability*, G. Junot, G. Briand, R. Ledesma-Alonso, and O. Dauchot, Phys. Rev. Lett. **119**, 028002, (2017).
5. *Self-propelled hard disks: implicit alignment and transition to collective motion* Khanh-Dang Nguyen Thu Lam, Michael Schindler, Olivier Dauchot New Journal of Physics (2015)