Research Topic for the ParisTech/CSC PhD Program

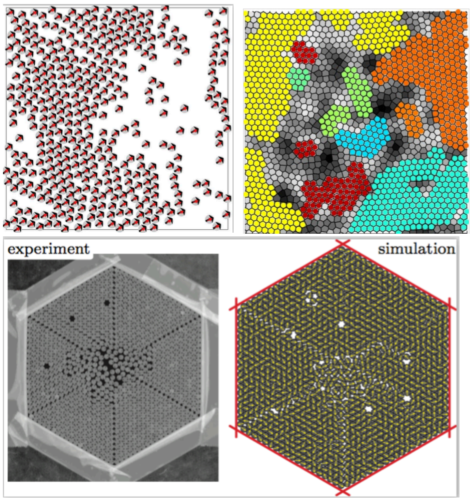
Subfield: Active Matter, Liquids, Glasses, Crystals, Statistical Physics

ParisTech School: ESPCI

Title: The dense phases of self-propelled hard disks

Advisor(s): Olivier Dauchot, olivier.dauchot@espci.fr, http://www.ec2m.espci.fr

Short description of possible research topics for a PhD:



Self-propelled hard disks describe the motion of vibrated polar grains, a model experimental system for dry active matter.
The two main phenomena specifically observed in systems of active particles, namely a transition to collective motion and a motility induced condensation transition, are prone to be observed in a system of self propelled hard disks.
On one hand, we have demonstrated in the past few years, that self propelled hard disks have a richer dynamics than the simplest model of Active Brownian Particles (ABPs). As a result they produce self alignment, which in turn leads to the emergence of collective motion. On the other hand, crowding effects, similar to those responsible for the glass transition of equilibrium hard disks, effectively slow down the characteristic velocity of the disks and should lead to the intensively studied Motility Induced Phase Separation (MIPS).

This has however not been established in the present case, and it is not clear how self-alignment would impact this scenario. More generally, although we have a very good understanding of the dilute phases of the system, little is known at finite densities.

The purpose of this thesis is to investigate the dense phases of our model of self-propelled hard disks. This includes tow main aspects:
- exploring the phase diagram at finite density and characterizing the different phases
- identifying the slow modes of the dynamics in the different phases, and extract their long time and large scale dynamics.

Required background of the student: The thesis will contain both theoretical and numerical work and is largely inspired by experimental observations. The applicant should have a good background in liquid state theory and statistical physics in general. He should be familiar with Molecular Dynamics simulations and at ease with standard computational tools. Good oral and writing communication in English is highly desirable.

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

1. Briand, G. & Dauchot, O. Crystallization of Self-Propelled Hard Discs. *PRL* **117,** 098004–5 (2016).
2. Nguyen Thu Lam, K.-D., Schindler, M. & Dauchot, O. Self-propelled hard disks: implicit alignment and transition to collective motion. *New Journal of Physics* **17,** 113056 (2015).
3. Nguyen Thu Lam, K.-D., Schindler, M. & Dauchot, O. Polar active liquids: a universal classification rooted in nonconservation of momentum. *J. Stat. Mech.* 1–21 (2015). 4. Weber, C. A. *et al.* Long-Range Ordering of Vibrated Polar Disks. *Phys. Rev. Lett.* **110,** 208001 (2013).
5. Deseigne, J., Dauchot, O. & Chaté, H. Collective Motion of Vibrated Polar Disks. *PRL.* **105,** (2010).