INTERNSHIP PROPOSAL

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Internship location: Luxembourg
Thesis possibility after internship: YES
Funding: YES If YES, which type of funding: University of Luxembourg

Nonequilibrium thermodynamics of pulsating active matter

Active matter emerged as the class of nonequilibrium systems where every constituent extracts energy from its environment to produce an autonomous sustained dynamics [1]. Examples of active systems can be either biological, such as swarms of bacteria, or synthetic, such as self-catalytic colloids in a fuel bath. The combination of self-propulsion and interactions leads to collective effects without any equilibrium equivalent [2].

Recently, some active models have focused on the collective dynamics of repulsive particles with oscillating shape [3]. It has been shown that shape oscillation alone can fluidize dense systems [4], and that it also promotes deformation waves in line with experiments for dense biological tissues [5]. Such waves lead to a rich family of dynamical patterns (see Fig. 1), which are reminiscent of instabilities observed in reaction-diffusion systems.

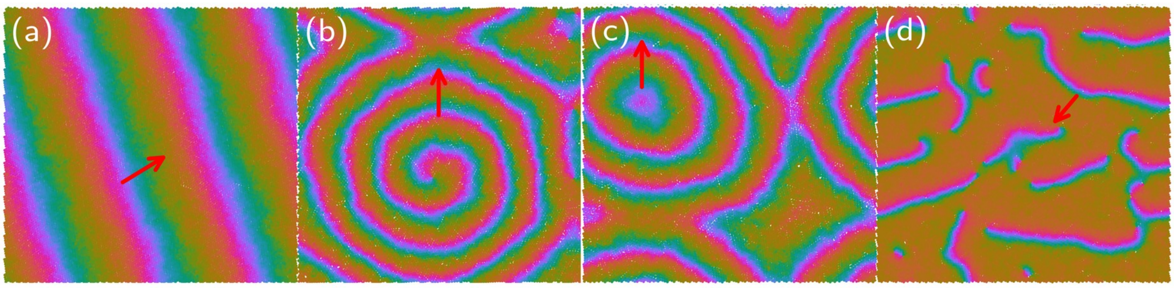

Figure 1: Waves of particle deformation spontaneously organize into various spatiotemporal patterns. Colors refer to particle sizes. Taken from [3].

The internship will study the thermodynamics of pulsating active matter. The project will use some recent methods of stochastic thermodynamics [6] and control theory [7] to evaluate how the dissipated energy correlates with pattern formation, and how to efficiently control pattern formation with external protocols. Overall, this study will largely build on the crosstalk between numerical and analytical methods of modern nonequilibrium statistical mechanics. In particular, the project will combine particle-based models and hydrodynamic theories.

The project can potentially lead to a fully funded PhD thesis in the Department of Physics and Materials Science at the University of Luxembourg, as part of the Physics of Active Matter group (https://efodorphysics.github.io/).

References

[1] Marchetti et al, Rev Mod Phys 85, 1143 (2013)
[2] Chaté, Annu Rev CMP 11, 189 (2020); Cates and Tailleur, Annu Rev CMP 6, 219 (2015)
[3] Zhang and Fodor, arXiv:2208.06831 (2022)
[4] Tjhung and Berthier, Phys Rev E, 96, 050601 (2017)
[5] Serra-Picamal et al, Nat Phys 8, 628 (2012)
[6] Seifert, Rep Prog Phys 75, 126001 (2012)
[7] Davis, Proesmans, Fodor, arXiv:2305.11078 (2023)