INTERNSHIP PROPOSAL

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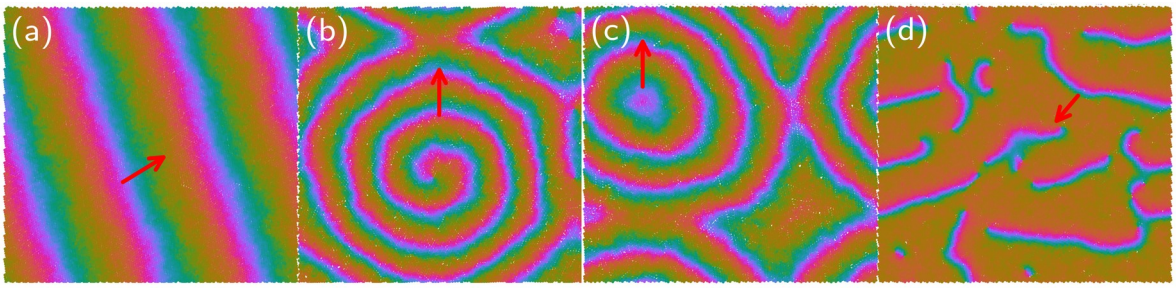
Internship location: Luxembourg
Thesis possibility after internship: YES
Funding: YES If YES, which type of funding: University of Luxembourg

Pulsating active springs

Active matter emerged in the last decade as the class of nonequilibrium systems where every constituent extracts energy from its environment to produce an autonomous directed motion [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, where the details of microscopic interactions distinguish different classes of dynamics. For instance, a collective polar motion for aligning particles [2], and a phase separation for repulsive isotropic particles [3].

Another class of models has focused more recently on active particles with oscillating shape. They have shown that shape oscillation alone can fluidize dense systems [4], and that it also promotes contraction waves, in line with experiments in dense biological tissues [5]. Such waves propagate without migration of particles, in contrast with polarization waves in systems of aligning self-propelled particles [2], yielding dynamical patterns reminiscent of reaction-diffusion systems [6] (see figure below, colors denote particle size),



The aim of this project is to build and to study a model of spring network, with oscillating properties at the individual level, which reproduces the wave propagation reported in the model of active deforming particles [5]. The study will largely build on the crosstalk between numerical and analytical methods of nonequilibrium statistical mechanics. The analytical descriptions 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 Condens Matter Phys 11, 189 (2020)
[3] Cates and Tailleur, Annu Rev Condens Matter Phys 6, 219 (2015)
[4] Tjhung and Berthier, Phys Rev E, 96, 050601 (2017)
[5] Serra-Picamal et al, Nat Phys 8, 628 (2012)
[6] Zhang and Fodor, arXiv:2208.06831 (2022)