Master 2: Physics of Complex Systems (PCS)

INTERNSHIP PROPOSAL

Laboratory name: Matière et Systèmes Complexes (MSC)
CNRS identification code: UMR 7057
Internship director's surname: **J.-B. FOURNIER & F. VAN WIJLAND**
E-mail: jean-baptiste.fournier@univ-paris-diderot.fr
E-mail: frederic.van-wijland@univ-paris-diderot.fr
Web page: See Google Scholar
Internship location: Matière et Systèmes Complexes (MSC)

Thesis possibility after internship: YES
Funding: Ecole Doctorale's contract

Active matter of switching particles interacting through an equilibrium statistical field

We study active matter in the form of switching particles that undergo interactions mediated by an otherwise fluctuating equilibrium field. This system is a paradigm for various biological and soft-matter out-of-equilibrium systems, e.g., active membrane proteins with ATP-dependent states, or switchable colloids.

We use both analytical tools (dynamical field theory, Dean-Kawasaki equations, nonlinear amplitude equations, etc.) and numerical simulations (Monte Carlo) to study these system, which develop various types of nonequilibrium patterns and bursts. In the miminal model, where the particles are described as active spins and the field is simply Gaussian, many open fundamental questions remain on the role of multibody interactions, that of the Casimir effect, or regarding the localization of dissipation (which we quantify by means of entropy production). There are also more practical questions that address the influence of the ratio of active to passive flips, the nature of the transition to the nonequilibrium state, the existence of universality classes, etc.

A definite step forward for this model system would be to bring it closer to realistic systems of experimental relevance, e.g., active membrane proteins. There, though the backbone of the model remains, the interactions between the Gaussian field and the embedded proteins involve higher-order derivatives. And the dynamics involves hydrodynamic couplings between the proteins, the field and their fluid environment. How these complications affect our early findings is unknown.