M2 internship - PhD

Active clusters

Active matter is a class of systems where a large number of discrete entities endowed with self-propulsion interact. Examples range from Janus colloids developed in the laboratory to bacteria colonies, mosquito swarms and bird flocks. Active matter is currently under intense scrutiny, as it exhibits properties that are uncommon in systems at thermodynamic equilibrium. One striking instance is the cluster phase, wherein **active particles spontaneously self-organize into transient groups** (figure). Such "active clusters" are broadly distributed in size, constantly move and evolve through particle exchange, internal fission or fusion with others. The cluster phase was investigated recently using an experimental realization based on self-propelled colloids [1], yet much remains to be understood.

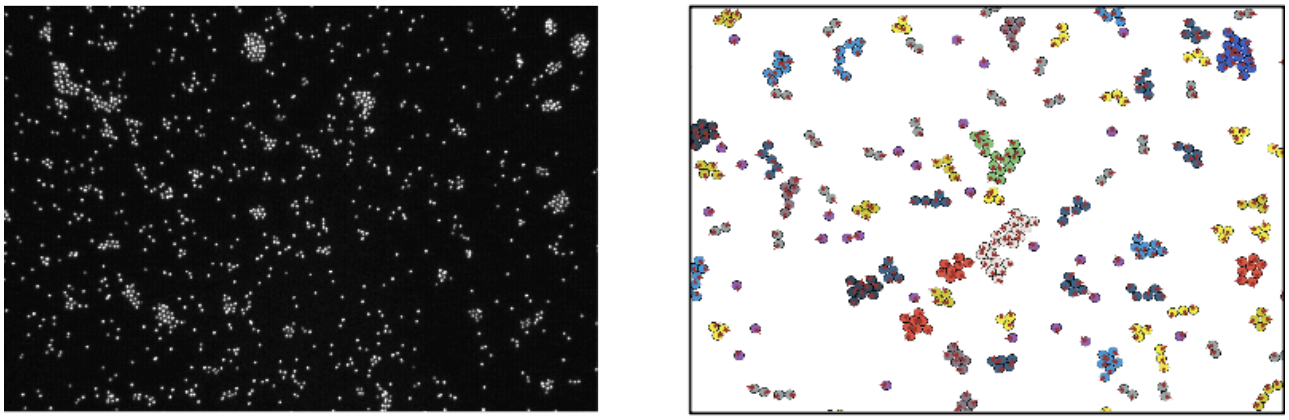

Figure: (Left) Active clusters of self-propelled colloids observed in experiments. (Right) Simulation of a minimal model.

The goal of the internship/PhD is to elucidate the nature of the cluster phase using numerical simulations of a minimal model. The advantages of this approach are twofold: first, simulations give access to properties that are inaccessible in experiments ; second, they will allow to investigate a variety of questions and situations that have remained unexplored so far. What are the required conditions to observe a cluster phase? Are the properties of the clusters system-specific or generic and predictable? How is the cluster phase modified by ordered and disordered environments?
The student will develop simulations of active clusters, analyze their statistical properties and build analytical models to rationalize the observed behavior. The work lies at the confluence of soft matter and statistical physics.

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[1] Ginot, Theurkauff, Detcheverry, Ybert, and Cottin-Bizonne. Aggregation-fragmentation and individual dynamics of active clusters. *Nature Communications* (2018).

Key-words: soft matter, active particles, statistical physics, numerical simulations.