Master de Physique Fondamentale et Appliquée
Université de Tours
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PROPOSITION DE STAGE DE MASTER 1

Emergent behaviour in active matter : A computational study of the Vicsek model

The *Vicsek model*, studies active matter and its collective behaviours, such as swarming and flocking. There, point-like self-propelled particles move and align their velocities with neighbouring particles. The Vicsek model captures the phenomenon of collective motion, where particles can spontaneously align to form large-scale ordered motion. This transition from disordered motion to ordered behaviour is marked by a first-order phase transition, with the system exhibiting a microphase separation between the disordered and ordered phases [1].

This project is an introduction to the study of active matter through the implementation and analysis of the Vicsek model. This includes developing a computational simulation to explore its core dynamics, such as the emergence of large-scale order and the phase transition from disordered to ordered states. Additionally, the project may involve extending the model to include real-world complexities, such as obstacles or heterogeneous particle properties, providing insights into how minimal models capture the universal features of collective behaviour.

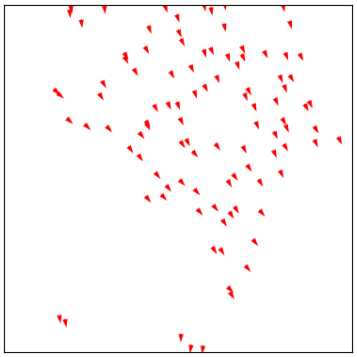

FIGURE 1 – Collective motion from Vicsek model : agents moving in an aligned direction.

Internship Focus

This internship is an introduction to the study of emergent phenomena in active matter systems. It will explore the modelling of collective behaviour in self-driven particles. Including :

- Understand the principles behind active matter and the Vicsek model.
- Implement simulation code to study the dynamics of the model.
- Develop tools to analyze the collective behaviour of particles, exploring the emergence of phase transitions.
- Develop visualization tools for particle trajectories and their collective motion.

Candidate Expectations

- A solid understanding of statistical physics and computational techniques, and a familiarity with numerical methods.
- Regular participation and satisfying grades to the Numerical Simulation and Statistical physics classes.
- Interest for complex systems, motivation for computational modelling.

Contact

Julien Garaud [julien.garaud@univ-tours.fr], Bureau E1230, Institut Denis Poisson, Université de Tours.

[1] F. Ginelli, « The Physics of the Vicsek Model », The European Physical Journal Special Topics **225**, 2099 (2015), arXiv :1511.01451 [cond-mat.soft].