SUJET DE STAGE

Laboratoire Interdisciplinaire de Physique, Grenoble

Collective effects in fish

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Context

The self-organization of groups of individuals is a fascinating phenomenon that can be found almost everywhere from a cycling peloton to flocks of starlings to herds of sheep. The collective behavior of fish is an astonishing example of coordinated movement that forms spontaneously on a large scale despite limited communication between individuals. In situ studies have identified the benefit of such schooling behavior: energy saving for swimming, visual effect for fighting a predator. Recently, experimental studies in the laboratory have also made it possible to test interaction models between individuals in a simple environment. Some phases of collective movements have been characterized by different dynamic models of non-equilibrium systems. We have recently proposed a model, purely orientational, which shows the gain in rheotaxis performance (alignment with respect to a flow) in the presence of collective interactions[1].

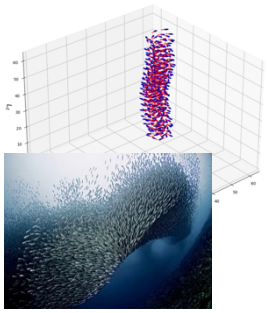

Fig. Elongated milling structure in our simulations and in nature.

Objective

We propose a numerical work. The objective of the internship is to study the dynamics of groups of fish in 3D. A preliminary work has already been carried out [4] and shows the emergence of new phases that appear and do not exist in 2D (i.e. the majority of models published in the literature) like elongated milling structures (see figure) or turning phases that appear because of the third dimension. A phenomenon that has to be understood!

Team :

This internship topic is part of a larger interdisciplinary project. Aurélie Dupont (LIPhy) [1,2,3,5] is working on the experimental part, Philippe Peyla (LIPhy) [1,2,3,5] on the modelling, Thibaut Métivet (INRIA) [5] and Bruno Ventéjou (LIPhy) [3,5] on the numerics and Christian Graff (LPNC) [2] on ethology. Weekly meetings with all partners are organized.

Keywords

physics of biological systems, active matter, collective motions, C++ programming.

The internship can be extended to a PhD.

Our recent publications on the topic

[1]Larrieu et al. Collective orientation of an immobile fish school and effect on rheotaxis. Phys. Rev. E103 022137 (2021)
[2]Larrieu et al. Forcing a fish school to a bottleneck: a smooth evacuation, Scientific Reports 13, 10414 (2023)
[3]Ventéjou et al, Collective behavior of a fish school in a crowded environment. (In preparation)
[4]Amaury Marchon, 3D Modeling of fish schools in complex environments. Master 1 Report, ENS-Lyon
[5]Ventéjou et al, A swimmer model. From Stokes to Navier Stokes flow. (In preparation)