INTERNSHIP-PhD PROPOSAL

Laboratory name: Laboratoire de Physique de l'ENS de Lyon
CNRS identification code: UMR 5672
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Internship location: ENS de Lyon
Thesis possibility after internship: YES Funding: Applications pending

FISH SCHOOLS AS SOFT ACTIVE MATTER

A school of fish turns in unison. A flock of birds twists to escape a predator. From a physicist's perspective, these mesmerizing scenes are puzzling: how can thousands of individuals, each with only local information, almost instantly synchronize their dynamics across system-spanning scales? One of our primary goals is to answer this question and explain the dynamics of animal collectives, relying only on basic physical principles.

To date, predicting how large groups respond to physical, social, or biological stimuli remains a significant scientific challenge. We address this gap by treating animal collectives as soft active matter: continua that flow, fluctuate, and reorganize on their own. We will establish their dynamics by acquiring and analyzing unprecedented datasets on multiple fish schools in natural environments (see images). We will then explain their spontaneous fluctuations and responses to predators by combining concepts from statistical mechanics and soft condensed matter, and tools from fluid mechanics and machine learning.

Top: A physicist induces a perturbation to the organization of 100m-long school of fish. Bottom: A

PhD candidates can be deeply involved at every stage of our investigations, from imaging large-scale natural systems, to performing statistical analyses and developing predictive mathematical models. Master's interns typically focus on analyzing data and/or contribute to the development of quantitative theories. For an introduction to the type of concepts and tools we would use, you can view our last study of human crowds as active fluids in [1].

We'd be delighted to discuss potential projects with you, either via Zoom or in Lyon.

[1] **Emergence of collective oscillations in massive human crowds** François Gu, Benjamin Guiselin, Nicolas Bain, Iker Zuriguel, and Denis Bartolo, Nature 638 112 (2025) ***[PDF here]***