Numerical and experimental study of phase transition in fish collective behavior

The aim of the proposed PhD project is to investigate some of the mechanisms that are responsible for phase transition in collective fish behavior, by coupling the experimental study of collective fish swimming with the numerical modeling of an interacting particle system.

The study of collective behavior has attracted much attention in the last twenty years, both among mathematicians and experimentalists, with the aim of explaining how local interactions between the group members lead to the emergence of global patterns, a phenomenon referred to as self-organization. Importantly, a group's capacity to transition between different global configurations is related to its survival capacity. For example, fish schools adopt different kinds of collective behavior when foraging for food or facing predators.

However, the mechanisms provoking phase transition in a group of interacting agents are often difficult to identify experimentally. This PhD project will focus on exploring the effect of two main mechanisms: (i) the individuals' fields of vision; and (ii) the population's heterogeneity. Since both mechanisms are particularly challenging to study exclusively by an experimental approach, this PhD project will aim at combining experiments with the numerical simulations of a mathematical model for interacting particles to investigate these two causes for phase transition in the school of fish. The project will rely on the tight collaboration between a team of physicists, who have great experience in experimental measurements and data processing, and a team of mathematicians, experts in the numerical and theoretical study of interacting particle systems.