Proposition de stage de Master
Institut de Physique de Nice — CNRS - UMR 7010

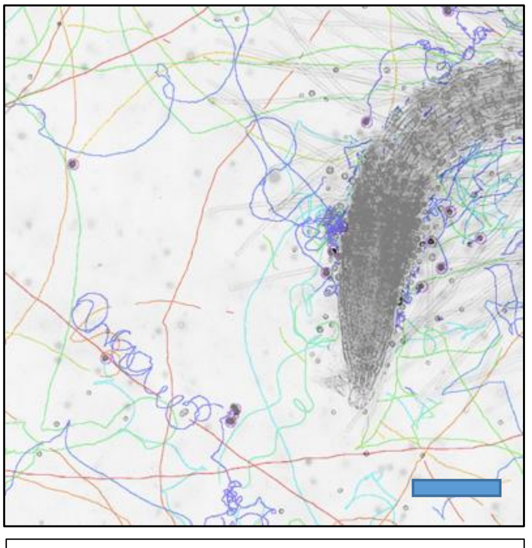
# Modeling interactions between a plant root and its microswimmer pathogen: from trajectories to attractive potential function

*Topics: modeling, mobility model, potential function, stochastic differential equation, biophysics of microorganisms, data analysis, active matter.*

Oomycetes are major plant pathogens that affect crops among which most of agronomic species and varieties. It is important to better characterize the mechanisms that govern plant-oomycete interactions in order to propose new methods of control environmentally friendly. In this context, we are studying the interaction between a model plant (*Arabidopsis thaliana*) and an oomycete (*Phytophthora parasitica*) to characterize root signals perceived by the pathogen. *P. parasitica* produces infectious particles called *zoospores* that swim in the soil to reach and infect the roots.

In recent years, we have developed an **interdisciplinary approach** with **plant biologists** (A. Attard and E. Galiana at ISA) and **physicists** (MIMIC team in INPHYNI). We characterized zoospores as a **new type of microswimmers** [1], and studied how they response to ionic gradients **using microfluidic devices** [2]. The present master work is a part of the evolution of this research project.

**Our project aims at define a potential function from microswimmers trajectories.**



*Example of trajectories:* zoospores are introduced in a microfluidic device in the presence of a root. The figure shows superposition of root image and zoospores trajectories reconstructed from TrackMate, an ImageJ pluggin . Bar: 100 µm.

We have previously performed experiments in microfluidic devices in which we observed zoospores swimming toward the root. We are able to follow the zoospores as they swim towards the root. The analysis results in the reconstruction of the trajectories (see figure).

Our goal is to use the trajectories to learn more about a putative attraction potential. It has been shown that it is possible to learn a potential function from trajectories and this has been applied to the movements of different mammals such as elk in the forest [3] or monk seals in an archipelago of islands [4].

Using the mathematical framework developed in these studies, combined with the modeling of zoospore movements, the master student will work on building new tools to define a potential from the movement of microorganisms: we will model the motion of “free” zoospores seen as *active* particles, then construct the statistical tools to deduce the significant changes of the displacements both in space and time when those particles are exposed to obstacles or to an external potential. This will be useful for the study of the interaction between the pathogen and the plant but also for other microorganisms like bacteria or algae.

**Supervisors:** **Yann BOURET** / 04 89 15 28 23 / Yann.BOURET@univ-cotedazur.fr
**Philippe THOMEN** / 04 89 15 28 57 / Philippe.THOMEN@univ-cotedazur.fr

[1] Quang D. Tran, et al. **Coordination of two opposite flagella allows high-speed swimming and active turning of individual zoospores**, (2022) eLife https://elifesciences.org/articles/71227
[2] Galiana E, et al. **Guidance of zoospores by potassium gradient sensing mediates aggregation.** J. R. Soc. Interface (2019) 16: 20190367.
[3] David R. Brillinger. **Learning a Potential Function From a Trajectory.** IEEE SIGNAL PROCESSING LETTERS, VOL. 14, NO. 12, DECEMBER 2007
[4] David R. Brillinger, et al. **A meandering hylje.** Festschrift for Tarmo Pukkila on his 60th Birthday 79 Eds. E. P. Liski, J. Isotalo, J. Niemelä, S. Puntanen, and G. P. H. Styan. Dept. of Mathematics, Statistics and Philosophy, Univ. of Tampere, 2006, ISBN 978-951-44-6620-5, pages 79–92