Programme du WorkShop DREAMS19 – 17 et 18 décembre 2019
DREAMS WorkShop Program19 - December 17 and 18, 2019

Mardi 17/12 (Tuesday)

Salle de Réunion Fizeau, 5ième étage (Fizeau Building, denoted 4 in the joint map, Floor 5)

A partir de 10h30 Accueil des Participants/Café
From 10:30 am Welcome of Participants/Coffee

11h00 : Introduction – Présentation du Projet DREAMS, Yves D'Angelo, LJAD.
Presentation of the DREAMS project: an interdisciplinary project
I shall first quickly present the biology of fungal networks: filamentous fungi, apexes, hyphae, thallus, mycelium, give many examples and insist on the multi-scale aspects. An essential diversion deals with combustion, flames, reactive flows, active fronts, which is also a multi-scale phenomenon. I will then draw a parallel between these two topics: random expanding (discrete) networks may yield active fronts. Finally, I will mention some possible other applications in industrial/energy networks, economy, human health, process bioengineering…

12h00 : Déjeuner/*Lunch*, sur place.

Salle de Réunion « Olivier Chesneau » 1er étage Bâtiment Fizeau (Fizeau Building, Floor 1)

14h00 -15h15 : A.M. Aziz-Alaoui ; Université du Havre *(Séminaire IMSC du LJAD)*
Complex Systems and Interaction Networks: Application to the Asymptotic Behavior of Networks of Reaction-Diffusion Systems in Neuroscience and Ecosystems
Neuroscience consists of the study of the nervous system and especially the brain. The neuron is an electrically excitable cell processing and transmitting information by electrical and chemical signaling, the latter via synapses, specialized connections with other cells. A. L. Hodgkin and A. Huxley proposed the first neuron model to explain the ionic mechanisms underlying the initiation and propagation of action potentials in the squid giant axon. Here, we are interested in the asymptotic behavior of complex networks of reaction-diffusion (PDE) systems of such neuron models. We show the existence of the global attractor and the identical synchronization for the network. We determine analytically, for a given network topology, the onset of such a synchronization. We then present numerical simulations and heuristic laws giving the minimum coupling strength necessary to obtain the synchronization, with respect to the number of nodes and the network topology.

15h15 – 16h00 : Claire Guerrier (LJAD Université Côte d'Azur)
Physiological modeling of a neuronal network: emergence of spontaneous rhythmic patterns in the pre-Bötzinger Complex.
The pre-Bötzinger Complex located in the ventral medulla in the brainstem is involved in the non conscious inspiration, where a network of hundreds of neurons fire regularly in phase with the hypoglossal nerve. The neurons' activity shows periodic patterns, with alternatively bursting and silent periods. Using a modeling approach and benchmarking of the model against experimental data, we predict that short-term plasticity may underlie a spontaneous rhythmic activity in this network, independently of the intrinsic neuronal properties.

16h Break 15 mn

Salle de Réunion « Olivier Chesneau » 1er étage Bâtiment Fizeau

16h15 - 17h00 : Laurent Monasse (LJAD Université Côte d'Azur)
Fisher/KPP models with memory for fungal growth and their numerical simulation
Fungal networks can be modeled as branching processes in which the branching occurs both on the apexes and on the existing network. Starting from simple branching laws similar to Ricci Catellier & D'Angelo, a fluid PDE model can be formally derived. Further simplification of the models in the large diffusion limit gives a Fisher/KPP model with memory. We first study the qualitative behaviour of both the parabolic model and the fluid model, especially the selection of progressive fronts. We then use these results to design efficient and accurate numerical schemes for their resolution.

17h00 – 17h45 : Vincent Bansaye (École Polytechnique)

Branching processes and asymmetric cell division

I will present models for cell division taking into account asymmetry at division and random transmission of a trait. I will show for two examples how spine techniques and the knowledge of branching processes in random environment allow to describe the profile of traits among the cell population. In particular, we are interested in the interplay of asymmetry and random transmission to capture the population with atypical traits. We will also link these issues to the description of bias in sampling and the analysis of PDE.

17h45 – 18h30 : Milica Tomasevic (École Polytechnique)

On a multi-type branching process modelling the development of a filamentous fungus

In this talk, a multi-type branching process that models the growth of the network of filaments of a filamentous fungus will be presented. The network is seen as a population of individuals that may branch, grow or fragment according to prescribed rules depending on their type. We will analyse the repartition of filaments in length and size and derive a growth-fragmentation PDE that it satisfies. The long-time behaviour of this PDE gives us insights about the order of magnitude of the population growth rate and as well of the rates with whom the different events happen in the network.

Repas le soir 20h ou 20h30 – *Social Dinner*

Restaurant à Nice (Les Sens http://www.les-sens-nice.fr/)

37 Rue Pastorelli 06100 Nice Tél: 09.81.06.57.00

Mercredi 18/12 (Wednesday)

Salle de Réunion «Olivier Chesneau» 1er étage Bâtiment Fizeau (Fizeau Building, Floor 1)

8h30 Accueil

9h00– 9h45 : Clara Ledoux/Eric Herbert (Université Paris-Diderot)

Characterization of the hyphal network growth dynamics in the filamentous fungus Podospora anserina

The success of filamentous fungi in colonizing their highly competitive habitats can be largely attributed to their ability to form a mycelium. This unique structure is an expanding interconnected network of branching hyphae.

By an interdisciplinary approach, we characterize the network structure of the filamentous fungus *Podospora anserina* under controlled conditions using temporal series of pictures of this living network. The high-resolution camera allows for the analysis of both the whole mycelium and individual hyphae. The main features of the evolution of the hyphal network, such as the total length of the mycelium, the number of connections, the number of apexes, and the intra-thallus surfaces can then be precisely quantified.

9h45– 10h30 : Guillermo Vidal Diez De Ulzurrun (IMB, Academia Sinica, Taipei)

Mathematical approaches to study the fungal network

Aiming to understand the complexity of the fungal network and the processes shaping it, we have developed a three-dimensional spatially explicit model that is able to simulate the interactions between fungi and different environmental stimuli. In addition, we created innovative image analysis tools to extract data from images of growing fungi that will serve to calibrate mathematical models and study fungal phenotypes in detail.

10h30 : Break 15 mn

10h45 – 11h30 : Louis Chevalier (Institut Jacques Monod)

The Mechanobiology of cell wall growth in filamentous fungi

The growth of walled cells, like bacteria, fungi and plants is limited by the expansion of the cell wall, a thin and stiff sugar-made layer encasing the plasma membrane. How cell wall mechanics adapts to rapid expansion is not known, in part because of the lack of imaging methods to monitor cell wall dynamics in live growing cells. Using the genetically tractable model *Aspergillus nidulans*, we implemented a sub-resolution imaging method to map cell wall thickness with nanometric resolution around live growing hyphae. Those data highlight specific patterns with thinner and softer cell walls at sites of tip growth and serve to decipher how single hyphae growth rates are linked to wall mechanics.

11h30 -12h15 : Patrick Perré (CentraleSupélec, Université Paris Saclay)

Joint work with Huan DU, Institute for Advanced Study, Shenzhen University, China

A lattice-based model of fungal growth

Fungi are among the most destructive agents of wood and wood-based products, resulting in the decrease of the building service life by breaking down lumber structures. This work presents a discrete lattice-based model to simulate mycelial growth, which explicitly incorporates tip extension, extension angle, anastomosis, and branching. The developed algorithm eliminates geometrical restriction of the lattice directions. Thus, it can generate realistic mycelial networks with low computational costs. Different growth conditions are reproduced via tropisms, which influence the tip dominant direction, such as thigmotropism that enables hyphae to bend around obstacles in structurally heterogeneous media. The validation of this model is implemented through an experiment focusing on the morphology and growth of Postia placenta, a species of brown rot fungi. Some model parameters are directly obtained from the experimental data, while others must be determined by inverse procedure. Finally, the presentation will focus on differences between 2D and 3D simulations, as well as the possibility to obtain the macroscopic behavior using relevant sets of continuous equations.

12h15 Déjeuner/*Lunch*

14h00 – 14h45 : Catherine Villard (Institut Pierre Gilles de Gennes)
Hyphae growth and branching under shear flow and confinement
The fungus *Candida albicans* is a commensal organism of the human mucosal surfaces that under specific conditions, such as immune deficiency, can invade through the epithelium and into the bloodstream, causing major failures of internal organs. We aim to better understand and characterize this invasiveness using microfluidic techniques leading to a control of the microenvironment. We will in particular focus on the biophysics of *C. albicans* filaments (hyphae) under conditions of shear flow and confinement.

14h45 - 15h30 : Marc Durand (MSC, Université Paris-Diderot)
Transport network of giant unicellular organism Physarum Polycephalum: interplay between flows & contractile activity.
In its vegetative phase, P. Polycephalum is made of thousands of undifferentiated cells fusing in a single, multinuclear cell, which can reach macroscopic sizes. This organism then develops a tubular network in which oscillatory flows are generated by the contraction of the membranous layer surrounding the "veins". From a physicist's perspective, the plasmodium can be seen as an active gel that is able, at short times, to generate and adapt contractile waves along the veins to generate peristaltic flows, and at long times to control actively its sol-gel transition to modify the network architecture. During this talk, I will show our first experimental results on flows and growth of *P. Polycephalum* transport network, and the interplay with its contractile activity. I will also show how spatial confinement affects these different quantities.

15h30 : Coffee Break/Discussions

Vers 17h00 - Fin du WorkShop - End of the WorkShop

Départs vers aéroport et gare.
Departures to the airport and train station.