ARBRE III - Réseau Branchement : L'Ecole

3ème réunion annuelle du GdR Branchement

Avignon, du 20 au 24 avril 2026

Programme

Lundi 20 avril 2026

- 09h30-10h00: Welcome coffee
- 10h00-10h15: Opening speech
- **10h15-11h55: Mini-course "Branching processes and random environments" (1/3) - Matt Roberts**
- **11h55-12h35: Absorption rate in Fleming-Viot systems and velocity in N-BBM - Eric Brunet**

  In the Flemming Viot system in one dimension, N particles diffuse with a drift towards the origin and get absorbed at the orgin. Whenever a particle is absorbed, it is reborn at the position of one of the remaining particles. In The N-BBM, N particles diffuse and branch at random times. Each time a branching event occurs, the leftmost particle is removed. These two systems are, in some sense similar. In my talk, I will highlight some similarities, but also some interesting differences.
- Lunch
- **14h00-14h40: Crossing a fitness valley in age-structured populations - Sarah Kaakai**

  The presence of older individuals in natural populations raises critical evolutionary questions: what influence do these individuals exert on population evolution? An example is the so-called Lansing effect, a transgenerational mechanism in which offspring born to older parents have shorter lifespans than those born to younger parents. This phenomenon has been observed across multiple species, but its underlying mechanisms remain debated. From an adaptive dynamics perspective, the persistence of such an effect, which apparently decreases individual fitness, is puzzling. However, if individuals carrying the Lansing mechanism can evolve more rapidly under intermediate mutation rates of power-law order, they could reach a fitter trait faster than those without it, hence ensuring the persistence of this strategy. This scenario is reminiscent of fitness valley crossing, where a population must pass through an intermediate state of reduced fitness to reach a trait of higher fitness. In this talk, I will extend the framework and results of Bovier, Coquille and Shadi (2019) on fitness valley crossing to an age-structured population dynamics, where individuals are characterized by both their age and a discrete trait. In particular, I will show how accounting for age structure introduces new mathematical challenges, requiring fine results for age-structured populations and renewal equations. Joint work with M. Doumic, M. Esser and S. Méléard.
- **14h40-15h20 : Empirical distribution of ancestral lineages in populations with density-dependent interactions - Madeleine Kubasch**

  We study a density-dependent Markov jump process describing a population where each individual is characterized by a type, and reproduces at rates depending both on its type and on the population type distribution. We are interested in the empirical distribution of ancestral lineages in the population process. First, we exhibit a time-inhomogeneous Markov process, which allows to capture the behavior of a sampled lineage in the population process. This is achieved through a many-to-one formula, which relates the expected value of a functional evaluated over the lineages in the population process to the expectation of the functional evaluated along this time-inhomogeneous process. This provides a direct interpretation of the underlying survivorship bias. Second, we consider the large population regime, when the population size grows to infinity. Under classical assumptions, the population type distribution converges to a deterministic limit. Here, we focus on the empirical distribution of ancestral lineages in this large population limit, for which we establish a many-to-one formula. Using coupling arguments, we further quantify the approximation error which arises when sampling in this large population approximation instead of the finite-size population process.
- Coffee break
- **15h50-17h30 : Mini-course "Phenomenological approaches to branching processes: heuristics for generating conjectures" (1/3) - Stéphane Munier**

Mardi 21 avril 2026

- **09h00-10h40: Mini-course "Branching processes for population genetics" (1/3) - Camille Coron**
- Coffee break
- **11h10-11h50: Harvesting primordial black holes from stochastic trees with FOREST - Pierre Auclair**

  The large-scale structure of our Universe is well-described as an expanding medium filled with tiny perturbations. As the Universe expands, these fluctuations grow and lead to the formation of large-scale structures and the cosmic microwave background we observe today. The main scenario to explain the origin of these initial fluctuations is called "cosmic inflation", a phase of exponential expansion during which quantum fluctuations become macroscopic and classical. In some extreme cases, large fluctuations may collapse and lead to the formation of "Primordial Black Holes", a candidate for Dark Matter. In this work, we proposed to model this exponential expansion as a branching process, the quantum fluctuations is modeled as a stochastic noise during the classical evolution of the Universe. We implement this scheme in FOREST (FOrtran Recursive Exploration of Stochastic Trees) and look for the formation of Primordial Black Holes directly inside the trees.

- **11h50-12h30: Symmetry breaking in bacterial colonies in a kinetic reaction–transport model - Maxime Estavoyer**

  We study the emergence of symmetry breaking in expanding bacterial colonies in the presence of a localized prey. While colony expansion is typically radially symmetric, environmental interactions can induce anisotropic propagation patterns. We introduce a kinetic reaction–transport model for motile and proliferating bacteria, combining persistent motion, stochastic reorientation, and division at the microscopic scale. From this description, we derive macroscopic equations for the bacterial density, leading to a nonlinear system governing colony dynamics. We analyze front propagation through travelling wave solutions and associated spreading speeds. We show that the presence of a prey alters the effective transport and proliferation terms, resulting in changes in front speed and triggering a breakdown of radial symmetry. Our approach combines analytical results, numerical simulations, and experimental data at both the colony and single-cell scales.

- Lunch
- **13h50-15h30: Mini-course "Phenomenological approaches to branching processes: heuristics for generating conjectures" (2/3) - Stéphane Munier**
- Coffee break
- **16h00-17h40: Mini-course "Branching processes and random environments" (2/3) - Matt Roberts**

Mercredi 22 avril 2026

- **09h00-10h40: Mini-course "Phenomenological approaches to branching processes: heuristics for generating conjectures" (3/3) - Stéphane Munier**
- Coffee break
- **11h10-11h50: Fluctuations around the limit of the derivative martingale of branching Brownian motion - Michel Pain**

  Branching Brownian motion is a particle system starting with one particle at the origin and where each particle moves according to a Brownian motion during an exponential lifetime before being replaced by a random number of children. A key quantity to study the near-maximal particles is the so-called derivative martingale, which converge to some limit Z_∞*. Various quantities describing the front of branching Brownian motion are known to converge towards multiples of* Z_∞*. I will present results concerning the 1-stable fluctuations that occur in these convergences, initiated in two joint works with Pascal Maillard and with a focus on an ongoing work with Xinxin Chen.*
- **11h50-12h30: Linear spreading speed in a branching annihilating random walk - Alice Callegaro**

  We study a branching-annihilating random walk in which particles evolve on the lattice in discrete generations. Each particle produces a Poissonian number of offspring which independently move to a uniformly chosen site within a fixed distance from their parent's position. Whenever a site is occupied by at least two particles, all the particles at that site are annihilated. This can be thought of as a very strong form of local competition and implies that the system is not monotone. For certain ranges of the parameters of the model, we show that the system dies out almost surely or, on the other hand, survives with positive probability. In an even more restricted parameter range, we strengthen the survival results to complete convergence with a non-trivial invariant measure, and in the same regime we show existence of a linear spreading speed for the model on the integer line. A central tool in the proofs is comparison with oriented percolation on a coarse-grained space-time lattice, using carefully tuned density profiles which expand in time and are reminiscent of discrete travelling wave solutions. Our results extend to (possibly non-monotone) models for which comparison with oriented percolation and other coupling techniques hold. Based on joint works with Matthias Birkner (Mainz), Jiří Černý (Basel), Nina Gantert (TU Munich) and Pascal Oswald.
- Lunch
- **14h00-15h40: Mini-course "Branching processes for population genetics" (2/3) - Camille Coron**
- **15h45-17h15: Poster session**

Jeudi 23 avril 2026

- **09h00-10h40: Mini-course "Branching processes and random environments" (3/3) - Matt Roberts**
- Coffee break
- **11h10-11h50: Limit theorems for branching random walk and parabolic Anderson model in Weibull environment - Vianney Brouard**

  We consider a branching random walk (BRW) on the lattice $\mathbb{Z}^d$, started with a single particle at the origin, where the branching rates are given by an i.i.d. Weibull random potential $(\xi(z))_{z\in\mathbb{Z}^d}$, that is with upper tail $Prob(\xi(0) \geq x) = \exp(-x^\gamma)$, for $x \geq 0$ and $\gamma > 0$. We also study the mean behaviour of the system by studying the corresponding parabolic Anderson model (PAM). Our focus is the long-term evolution of both systems. After an appropriate rescaling in space, we prove convergence of the asymptotic expansions for the logarithm of the number of particles, respectively the solution of the PAM, uniformly over all sites z contained in a growing to infinity ball (in the rescaled space) up to the first random term. The limiting random terms of the expansions are characterised as solutions of explicit time-linear variational problems that balance a linear function of the height of a high peak of the environment and of their neighbours in the ball of radius $\lfloor(\gamma-1)/2\rfloor$, with the cost of travelling to and from this peak. We also prove convergence of the local profile of the environment around the peaks solving the variational problems. A key consequence of our study is that the BRW and the PAM exhibit identical asymptotic expansions for all Weibull exponents $\gamma > 0$ up to the first random term, in sharp contrast with the Pareto case. This establishes for the first time that the PAM provides an asymptotically accurate approximation to the BRW. This talk is based on a joint work with Marcel Ortgiese and Matt Roberts.

- **11h50-12h30: Parameter estimation for cell division data - Benoîte de Saporta**

  The aim of this study is to statistically investigate the division mechanism for single cell organisms. We use an asymmetric growth-fragmentation model suitable for cell division that takes into account both the size and age of the cells as well as their type. We compare several estimation strategies for the dynamics parameters (elongation rate, proportion of the size of the mother inherited by the daughter cells, life-time distributions) taking into account the branching nature of the phenomenon, measurement noise, and the fact that observations are only available in discrete time. This is a joint work with Alice Cleynen (CNRS), Bertrand Cloez (Inrae), Nathalie Krell (Univ Rennes), Tristan Roget (Univ Montpellier) and Amélie Vernay (Univ Montpellier)

- Lunch break
- **14h00-15h40: Mini-course "Branching processes for population genetics" (3/3) - Camille Coron**
- Coffee break
- **16h10-16h50: Controlled Interacting Branching Diffusion Processes: A Viscosity Approach - Antonio Ocello**

  In this talk, I will present recent results on optimal control problems for interacting branching diffusion processes, a class of measure-valued stochastic systems that combine spatial motion with birth–death mechanisms. These models naturally arise in applications where both population dynamics and spatial interactions must be taken into account. From a dynamic programming perspective, we establish a rigorous connection between this control problem and an infinite system of coupled Hamilton–Jacobi–Bellman (HJB) equations. This is achieved through a representation of particle configurations as a disjoint union of Euclidean spaces of varying dimensions, allowing us to bring tools from viscosity solution theory into this infinite-dimensional setting. Under natural growth conditions on the cost functionals, we show that the associated value function satisfies similar bounds and can be characterized as a viscosity solution of the corresponding HJB system. We also establish a comparison principle, leading to a complete characterization of the control problem through the HJB formulation. Finally, I will discuss a simplified formulation arising in a mean-field regime where the model exhibits permutation symmetry between individuals. Exploiting this structure, we show that the control problem can be reduced to symmetric controls, using a combination of viscosity solution techniques and measurable selection arguments. This talk is based on https://arxiv.org/abs/2601.11294 .

- **16h50-17h30: Branching process applications in the context of antibiotic resistance evolution - Peter Czuppon**

  Branching processes have a long history in population genetics, where they have been used since 100 years to compute the fixation probability of a novel beneficial mutation in a population. While population genetics models have become more involved, branching processes are still the key tool to compute fixation or extinction probabilities of novel genetic variants. In this presentation, I will study two applications in the context of antibiotic resistance evolution during antibiotic treatment. First, in a model with exactly two genotypes, corresponding to antibiotic-sensitive and -resistant bacteria, I will discuss the effect of different antibiotic types (affecting birth or death rates) and two modes of density regulation on the establishment probability of a resistant population during treatment. In a second example, I will study a K-types model with mutations between the different types. Moreover, the antibiotic concentration may vary over time. Here, we will use Laplace exponents of a Feller diffusion to approximate the survival of the bacterial population. We identify an ordinary differential equation governing the Laplace exponents, which ultimately allows us to efficiently compute the probability of extinction of the bacterial population.

- 19h30-...: Conference dinner (Grand Café Barretta, 14 place Saint-Didier)

Vendredi 24 avril 2026

- **09h00-09h40: Descent-biased trees and dendrons - Paul Thévenin**

  Descent-biased trees are random trees depending on one parameter, which interpolate between two well-known models of trees: uniform random trees and random recursive trees. We investigate the convergence of descent-biased trees of large size, and characterize their limit. In particular, in some critical regime, the limit is a random dendron, structure that was formally introduced recently by Elek and Tardos as a generalization of trees. Dendrons describe all possible limits of random trees which converge in a weak sense. Our methods are a mix of probabilistic estimates, study of random permutations and analytic combinatorics. This is a joint work with Victor Dubach (Uppsala University, Sweden) and Stephan Wagner (TU Graz, Austria).

- **09h40-10h20: A new family of random spaces built from stable snakes - Ariane Carrance**

  The Brownian sphere is a random continuum metric space, which is universal in the sense that it is the scaling limit of many families of random planar maps. The study of the Brownian sphere hinges on its natural construction from the Brownian snake, i.e. a Brownian tree endowed with Brownian spatial displacements. In a recent joint work with Eleanor Archer and Laurent Ménard, we introduce and study its generalisation to the case of alpha-stable trees, with 1<alpha<2. The resulting "stable spheres" are expected to be the scaling limits of specific random models of planar maps, with heavy-tailed vertex degrees. In this talk, I will present the construction of these continuum and discrete models and the main properties that we have obtained so far. I will emphasise the main differences between these models and another notable class of random maps with a stable flavor, called Boltzmann random maps, and explain how these differences give rise to interesting challenges to study our new model further. I will also highlight some new results on stable snakes that we have established along the way, which might be useful for other applications.

- Coffee break

- **10h50-11h30: A FKPP system and its dual process - Nathanaël Boutillon**

  I will focus on a system of FKPP equations with Allee effect. This system can model interacting species with spatial structure and with cooperation among species. I will show how to construct a dual process to such a system, based on a branching Brownian motion. The dual process will allow us to find spreading properties of this system, overcoming some of the difficulties raised by the Allee effect (which prevents us in particular from linearising the system). Joint work with João Luiz de Oliveira Madeira.

- **11h30-12h10: Fluctuations for fully pushed stochastic fronts - Thomas Hughes**

  This talk concerns travelling wave solutions to stochastic reaction diffusion equations, such as those arising in population genetics to model the genetic composition of an evolving spatial population. Different reactions are expected to correspond to three varieties of travelling waves, pushed, semi-pushed, and pulled, which exhibit different behaviours under noisy perturbation. I will discuss a recent work examining the behaviour of the front in the (fully) pushed regime, which includes both bi-stable and mono-stable reactions. Our main result precisely characterizes the limiting deviation of the position of the front from its "deterministic" position, in a certain scaling regime, as a Brownian motion with drift. This is joint work with Alison Etheridge, Raphaël Forien and Sarah Penington.

- Lunch