The sixth Bath-Beijing-Paris meeting

Branching structure days

followed by

Nuclear days

Monday 13th to Friday 17th September 2022

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About

The BBP6 Branching structures meeting

The sixth Bath-Beijing-Paris branching structures meeting will be held online, and will be an opportunity to discuss a broad family of stochastic models which exhibit branching phenomena, including applications to neutron transport. As a new feature for this series of meetings, the meeting will run in extended form for five days split into two components.

The first three days are devoted to random branching structures such as branching random walks, fragmentation and coalescence processes, and population models, as well as other probabilistic models.

The last two days are devoted more specifically to an application area of branching structures. For this edition of the workshop, we will focus on recent innovations in the theory of neutron transport and its connection to quasi-stationarity, Monte-Carlo simulation and numerical stochastic methods.

Organising committee

Julien Berestycki	Alex Cox	Andreas Kyprianou	Pascal Maillard
Bastien Mallein	Sarah Penington	Matt Roberts	

Timetable

Branching structure days

Monday 13th September

13:30–13:50	**Gathering on Gathertown**	
13:50–14:00	**Opening of the conference**	
14:00–14:25	**Louigi Addario-Berry** McGill University, Canada	Height bounds for random trees
14:30–14:55	**Leonid Mytnik** Technion, Israel	Limiting behavior of the extremal process of branching Brownian motion
15:00–15:15	**Coffee break**	
15:15–15:40	**Christina Goldschmidt** University of Oxford, United Kingdom	The scaling limit of a critical random directed graph
15:45–16:10	**Alice Callegaro** University of Bath, United Kingdom	A spatially-dependent fragmentation process
16:15–16:30	**Coffee break**	
16:30–16:55	**Manon Costa** Université Paul Sabatier, France	Emergence of homogamy in a two-loci stochastic population model
17:00–17:30	**Social gathering on Gathertown**	

Tuesday 14th September

13:30–14:00	**Informal discussion on Gathertown**	
14:00–14:25	**Lisa Hartung** Universität Mainz, Germany	The structure of the extreme levels in the 2d discrete Gaussian free field
14:30–14:55	**Roman Stasinski** University of Oxford, United Kingdom	Where are the faraway particles of the branching Brownian motion in dimension d?
15:00–15:15	**Coffee break**	
15:15–15:40	**Marcel Ortgiese** University of Bath, United Kingdom	The largest degree in weighted recursive trees
15:45–16:10	**Nic Freeman** University of Sheffield, United Kingdom	Weaves, webs and flows
16:15–16:30	**Coffee break**	
16:30–16:55	**Jason Schweinsberg** UCSD, United States	Yaglom-type limit theorems for branching Brownian motion with absorption
17:00–17:30	**Poster session on Gathertown**	

Wednesday 15th September

13:30–14:00	**Informal discussion on Gathertown**		
14:00–14:25		**Zhenyao Sun** Technion, Israel	Effect of small noise on the speed of reaction-diffusion equations with non-Lipschitz drift
14:30–14:55		**Julie Tourniaire** Université Paul Sabatier, France	Spatial dynamics of a population in a heterogeneous environment
15:00–15:15	**Coffee break**		
15:15–15:40		**Daniel Kious** University of Bath, United Kingdom	Finding geodesics on graphs using reinforcement learning
15:45–16:10		**Felix Foutel-Rodier** Université Sorbonne Université, France	Exchangeable coalescents, ultrametric spaces, and combs
16:15–16:30	**Coffee break**		
16:30–16:55		**Emmanuel Schertzer** University of Wien, Austria	Probabilistic models related to the SARS-CoV-2 pandemic
17:00–17:30	**Closure of Branching Structure Days**		

Neutron Transport Days

Thursday 16th September

9:00 – 10:00		**Emma Horton** INRIA Bordeaux	Course 1: Stochastic Analysis of the Neutron Transport Equation
10:30 – 11:30		**Emma Horton** INRIA Bordeaux	Course 2: Stochastic Analysis of the Neutron Transport Equation
11:30 – 12:45		**Pierre del Moral** INRIA Bordeaux	TBC
12:45–14:30	**Lunch**		
14:30–15:15		**Tony Lelièvre** Ecole des Ponts, ParisTech	TBC
15:15–16:00		**Eric Dumonteil** IRFU, CEA-Saclay	Neutron clustering: from the gambler's ruin to reactor physics
16:00–16:30	**Coffee**		
16:30-17:15		**Andi Wang** University of Bristol	Quasi-stationary Monte Carlo methods
17:15–18:00		**Minmin Wang** University of Sussex	Branching process inspired approaches to the neutron transport equation

Friday 17th September

9:00 – 10:00		**Alexander Cox** University of Bath	Course 3: Monte Carlo methods and challenges for the neutron transport equation
10:30 – 12:15		**Open Problem Session**	
12:15 – 13:00		**Mathais Rousset** INRIA Rennes	TBC
13:00–15:00	**Lunch**		
15:00–15:45		**Jere Koskela** University of Warwick	Nonreversible MCMC for discontinuous targets and disconnected spaces with boundaries
15:45–16:30		**Denis Villemonais** Université de Lorraine	Almost sure convergence of Measure Valued Polya Processes
16:30–17:00	**Coffee**		
17:00-17:45		**Alex Watson** University College, London	Growth-fragmentation and quasi-stationary methods
17:45–18:00		**Wrap up**	

List of Abstracts – Talks

Monday 13th

Height bounds for random trees

Louigi Addario-Berry
McGill University, Montreal, Canada

I will present new, non-asymptotic bounds on the heights of random combinatorial trees and conditioned Bienaymé trees, as well as a stochastic inequality relating the heights of combinatorial trees of the same size but with different degree sequences. The tool for all the proofs is a new approach to coding rooted trees by sequences.
Based on joint work with Serte Donderwinkel, Mickaël Maazoun and James Martin.

Limiting behaviur of the extremal process of branching Brownian motion

Leonid Mytnik
Technion, Israel

We consider the limiting extremal process $\mathcal{X}$ of the particles of the binary branching Brownian motion. We show that after a shift by the logarithm of the derivative martingale Z, the rescaled "density" of particles, which are at distance $n+x$ from a position close to the tip of $\mathcal{X}$ converges in probability to a multiple of the exponential e^x as $n \to \infty$. We also show that the fluctuations of the density, after another scaling and and additional random but explicit shift converge to a 1-stable random variable. Our approach uses analytic techniques and is motivated by the connection between the properties of the branching Brownian motion and the Bramson shift of the solutions to the Fisher-KPP equation with some specific initial conditions. The proofs of the imit theorms rely crucially on the fine asymptotics of the behavior of the Bramson shift for the Fisher-KPP equation starting with "small" initial condition.
This talk is based on joint works with L .Ryzhik and J.-M. Roquejoffre.

The scaling limit of a critical random directed graph

Christina Goldschmidt
University of Oxford, United Kingdom

We consider the random directed graph $D(n,p)$ with vertex set $\{1,2,\ldots,n\}$ in which each of the $n(n-1)$ possible directed edges is present independently with probability p. We are interested in the strongly connected components of this directed graph. A phase transition for the emergence of a giant strongly connected component is known to occur at $p = 1/n$, with critical window $p = 1/n + \lambda n^{-4/3}$ for $\lambda \in \mathbb{R}$. We show that, within this critical window, the strongly connected components of $D(n,p)$, ranked in decreasing order of size and rescaled by $n^{-1/3}$, converge in distribution to a sequence of finite strongly connected directed multigraphs with edge lengths which are either 3-regular or loops.
This is joint work with Robin Stephenson (Sheffield).

A spatially-dependent fragmentation process

Alice Callegaro
University of Bath, United Kingdom

We define a fragmentation process in which rectangles break up into progressively smaller pieces at rates that depend on their shape. Long, thin rectangles are more likely to break quickly, and are also more likely to split along their longest side. We are interested in the evolution of the system at large times: how many fragments are there of different shapes and sizes, and how did they reach that state? We give an almost sure growth rate along paths by studying an equivalent branching random walk with spatially dependent rates. The talk is based on a joint work with Matt Roberts.

Emergence of homogamy in a two-loci stochastic population model

Manon Costa
Université Paul Sabatier, Toulouse, France

In this talk we study the emergence of a specific mating preference pattern called homogamy in a population. Homogamy corresponds to the case where individuals are more likely to reproduce when they have similar phenotype/genotype. This mating pattern is supposed to promote diversity within communities. Here we proposed an individual based model in which individuals are characterized by their genotype at two haploid loci (one for phenotype, the second for mating preference), and the population dynamics is modeled by a non-linear birth-and-death process. We are interested in the probability and time of invasion of homogamous reproduction within a population which mates uniformly at random.

Tuesday 14th

The structure of the extreme levels in the 2d discrete Gaussian free field

Lisa Hartung
Universität Mainz, Germany

In this talk we take a closer look at the extreme level sets of the 2d discrete Gaussian free field. The extremes can be described by a decorated Poisson point process. The Poisson points correspond to extreme local maxima and the decoration to field around these extreme local maxima. We obtain quantitative estimates on the number of sites at which the field is above a certain fixed distance from the order of the global maximum. We also study, for a randomly chosen particle from an extreme level set, the spatial distance and height difference to the extreme local maximum. Based on joint work with M. Fels and O. Louidor.

Where are the faraway particles of the branching Brownian motion in dimension d?

Roman Stasinski
University of Oxford, United Kingdom

Branching Brownian motion is a basic model in which particles move in space according to the Brownian motion, and branch independently of the movement. Its behavior in the one dimensional setting is well understood, especially the picture emerging around the particle which is the furthest from the origin at some large time t. On the other hand much less is known about the multidimensional case.
In this talk we start with reviewing the main results on the position of the extremal particles in the one dimensional BBM, where the so called 'derivative martingale' plays a major role. Then we introduce a generalization of this martingale to multiple dimensions, viewed as a process in time on the sphere $\mathbb{S}^{d-1}$, and formulate a conjecture on the angular position of the extremal particle in $\mathbb{R}^d$. Finally, we present a sketch of the proof of the theorem stating that the limit, when we let t to infinity, of this derivative martingale on $\mathbb{S}^{d-1}$ is well defined.
This is based on a joint work with Julien Berestycki and Bastien Mallein.

The largest degree in weighted recursive trees

Marcel Ortgiese
University of Bath, United Kingdom

The classical random recursive tree is a model of an evolving tree, where at each time step a new vertex arrives that is then connected to one of the predecessors uniformly at random. We consider a variation, where we associate to each vertex a (random) weight and the newly incoming vertex connects to one of the old vertices with probability proportional to its weight. In this talk, the main quantity of interest is the growth of the largest degree. We will see that the asymptotics of the largest degree are the result of a competition between old vertices that had more time to grow and new vertices with very high weights. Depending on the tail of the weight distribution, we can make very fine statements about the growth of the largest degree, in some cases down to random fluctuations. In general, very different behaviour emerges when we compare bounded weight distributions with unbounded and more heavy-tailed distributions.
Joint work with Laura Eslava and Bas Lodewijks.

Weaves, webs and flows

Nic Freeman
University of Sheffield, United Kingdom

We consider "weaves" - loosely, a weave is a set of non-crossing cadlag paths that covers 1+1 dimensional space-time. Here, we do not require any particular distribution for the particle motions. Weaves are a general class of random processes, of which the Brownian web is a canonical example; just as Brownian motion is a canonical example of a (single) random path. It turns out that the space of weaves has an interesting geometric structure in its own right, which will be the focus of the talk. This structure provides key information that leads to an accessible theory of weak convergence for general weaves. Joint work with Jan Swart.

Yaglom-type limit theorems for branching Brownian motion with absorption

Jason Schweinsberg
UCSD, United States

We consider one-dimensional branching Brownian motion in which particles are absorbed at the origin. We assume that when a particle branches, the offspring distribution is supercritical, but the particles are given a critical drift towards the origin so that the process eventually goes extinct with probability one. We establish precise asymptotics for the probability that the process survives for a large time, building on previous results by Kesten (1978) and Berestycki, Berestycki, and Schweinsberg (2014). We also prove a Yaglom-type limit theorem for the behavior of the process conditioned to survive for an unusually long time, providing an essentially complete answer to a question first addressed by Kesten (1978). An important tool in the proofs of these results is the convergence of a certain observable to a continuous state branching process. This is joint work with Pascal Maillard.

Wednesday 15th

Effect of small noise on the speed of reaction-diffusion equations with non-Lipschitz drift

Zhenyao Sun
Technion, Israel

We consider the $[0,1]$-valued solution $(u_{t,x} : t \geq 0, x \in \mathbb{R})$ to the one dimensional stochastic reaction diffusion equation with Wright-Fisher noise $\partial_t u = \partial_x^2 u + f(u) + \epsilon\sqrt{u(1-u)}\dot{W}$. Here, W is a space-time white noise, $\epsilon > 0$ is the noise strength, and f is a continuous function on $[0,1]$ satisfying $\sup_{z\in[0,1]} |f(z)|/\sqrt{z(1-z)} < \infty$. We assume the initial data satisfies $1 - u_{0,-x} = u_{0,x} = 0$ for x large enough. Recently, it was proved in (Comm. Math. Phys. **384** (2021), no. 2) that the front of u_t propagates with a finite deterministic speed $V_{f,\epsilon}$, and under slightly stronger conditions on f, the asymptotic behavior of $V_{f,\epsilon}$ was derived as the noise strength ϵ approaches ∞. We complement the above result by obtaining the asymptotic behavior of $V_{f,\epsilon}$ as the noise strength ϵ approaches 0: for a given $p \in [1/2, 1)$, if $f(z)$ is non-negative and is comparable to z^p for sufficiently small z, then $V_{f,\epsilon}$ is comparable to $\epsilon^{-2\frac{1-p}{1+p}}$ for sufficiently small ϵ. This is based on a joint work with Clayton Barnes and Leonid Mytnik.

Spatial dynamics of a population in a heterogeneous environment

Julien Tourniaire
Université Paul Sabatier, Toulouse, France

In the context of climate change, there has been a renewed interest in the dynamics of natural species' range. In this work, we investigate the impact of a slowly varying media on the propagation speed of a population. This question has been widely studied from the PDE point of view. However, the results given by the viscosity solutions theory turns out to be biologically unsatisfactory in some situations. We thus suggest to study an individual based model for front propagation in the limit when the scale of heterogeneity of the environment tends to infinity. In this framework, we show that the spreading speed of the population may be much slower than the speed of the front in the PDE describing the large population asymptotics of the system. More precisely, we prove that the rescaled position of the rightmost particle converges to the solution of a certain ODE. This disagreement between the two approaches is related to the so-called tail problem observed in PDE theory, due to the absence of local extinction in FKPP-type equations.
Based on joint work with Pascal Maillard and Gaël Raoul.

Finding geodesics on graphs using reinforcement learning

Daniel Kious
University of Bath, United Kingdom

The premise of our talk will be the fact that ants are believed to be able to find shortest paths between their nest and the sources of food by successive random explorations, without any mean of communication other than the pheromones they leave behind them.
We will discuss a work in collaboration with Bruno Schapira and Cécile Mailler in which we introduce a general probabilistic model for this phenomenon, based on reinforcement-learning. We will present various variants of the model, with slightly different reinforcement mechanisms, and show that these small differences in the rules yield significantly different large-time behaviors. In the version called the loop-erased ant process, we are able to prove that the ants manage to find the shortest paths on all series-parallel graphs.

Exchangeable coalescents, ultrametric spaces, and combs

Félix Foutel-Rodier
Université Sorbonne Université, Paris, France

An exchangeable coalescent is a partition-valued process that encodes the genealogy of a population. Alternatively, a genealogy can be seen as an abstract random ultrametric measure space. In this talk, I will introduce a third representation of a genealogy called a comb, that unifies both approaches. First, I will show that any exchangeable coalescent can be obtained through a sampling procedure based on a comb. This provides an extension to coalescents of Kingman's paintbox construction of exchangeable partitions. Second, a comb can be seen as a planar embedding of an abstract ultrametric space. I will show that, in an appropriate sense, any ultrametric space admits such an embedding. This extends earlier results from Lambert and Uribe Bravo that were restricted to compact spaces, and highlights the key measure theoretic assumptions needed to account for random ultrametric measure spaces that are not separable.

Probabilistic models related to the SARS-CoV-2 pandemic

Emmanuel Schertzer
Universität Wien, Austria

In this talk, we will discuss a few projects initiated by the SMILE group (College de France/Sorbonne Université) during the SARS-CoV-2 pandemic. I will present a general and tractable framework for modeling and "nowcasting" the epidemic. Our approach is based on a fairly general individual based model capturing the main features of the epidemic (presence of asymptomatics, large heterogeneity in the population etc.). We show that despite the underlying complexity of our microscopic model, the global scale of the epidemic (i.e., when the number of infected gets large) is well captured by a deterministic McKendrick–Van Foerster 1d PDE. I will also show how this approach allows to make some theoretical predictions on contact-tracing data.

List of Participants

Louigi Addario-Berry	McGill University, Canada
Alexander Alban	University Mainz, Germany
Daniel Amankwah	University of Iceland, Island
Eleanor Archer	Tel Aviv University, Israel
Vincent Bansaye	Ecole polytechnique, France
Matyas Barczy	University of Szeged, Hungary
Julien Berestycki	University of Oxford, United Kingdom
Gabriel Hernan Berzunza Ojeda	University of Liverpool, United Kingdom
Erion-Stelios Boci	University of Bath, United Kingdom
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