Activity Report 2017

Project-Team TOSCA

TO Simulate and CAlibrate stochastic models

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Project-Team TOSCA

Creation of the Project-Team: 2007 January 01

Keywords:

Computer Science and Digital Science:
> A6.1.2. - Stochastic Modeling (SPDE, SDE)
> A6.1.3. - Discrete Modeling (multi-agent, people centered)
> A6.1.4. - Multiscale modeling
> A6.2.2. - Numerical probability
> A6.2.3. - Probabilistic methods
> A6.2.4. - Statistical methods
> A6.4.2. - Stochastic control

Other Research Topics and Application Domains:
> B1.1.8. - Evolutionnary biology
> B1.1.10. - Mathematical biology
> B1.2.1. - Understanding and simulation of the brain and the nervous system
> B3.2. - Climate and meteorology
> B3.3.4. - Atmosphere
> B4.3.2. - Hydro-energy
> B4.3.3. - Wind energy
> B9.4.2. - Mathematics
> B9.9.1. - Environmental risks
> B9.9.2. - Financial risks

1. Personnel

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2. Overall Objectives

2.1. Overall Objectives

TOSCA aims to significantly contribute to discern and explore new horizons for stochastic modeling. To this end we need to better understand the issues of stochastic modeling and the objectives pursued by practitioners who need them: we thus need to deeply understand other scientific fields than ours (e.g., Fluid Mechanics, Ecology, Biophysics) and to take scientific risks. Indeed, these risks are typified by the facts that often new and complex models do not behave as expected, mathematical and numerical difficulties are harder to overcome than forecast, and the increase of our knowledge in target fields is slower than wished.

In spite of these risks we think that our scientific approach is relevant for the following reasons:

- On the one hand, physicists, economists, biologists and engineers use a stochastic model because they cannot describe the physical, economical, biological, etc., experiment under consideration with deterministic systems, either because the experiment has a huge complexity, or because accurate calibrations of the parameters of the models would be impossible. However it is far from being enough to add noise to a dynamical system or to substitute random variables as parameters: the probability distribution of the random noises and parameters themselves is a modeling issue and, in addition, the qualitative behavior of the model may dramatically change as a function of this choice; in other terms, adding randomness to capture uncertainties may increase uncertainty instead of aiding. This issue is not so well understood in the literature, where most often probabilistic structures are given A PRIORI rather than studied as questionable choices. **Therefore our works, which concern application fields where stochastic modeling is still in its very beginning, include analysis of the limitations of the models we are elaborating. This analysis is based, either on theoretical estimates, or on our unique experience in stochastic simulations.**

- On the other hand, STOCHASTIC COMPUTATIONAL MODELS are being developed here and there, including by our team, with a fully different point of view from classical modeling approaches: these models are aimed to approximate complex physical laws (e.g. Fluid Mechanics laws for turbulent flows or folding processes for proteins) by statistical properties of artificial objects (e.g. particles interacting with turbulent flows or low dimensional stochastic systems having suitable correlation structures). The design of the stochastic dynamics of these objects is part of the problem to deal with, and the complexity of the underlying physical phenomena leads to huge simulation difficulties. **Therefore we are exploring new frontiers for stochastic numerical methods and developing advanced techniques far beyond our previous works and most of the literature.**

To bring relevant analytical and numerical answers to the preceding problems, we feel necessary to attack in parallel several problems arising from different fields. Each one of these problems contributes to our better understanding of the advantages and limitations of stochastic models and algorithms.

Of course, this strategy allows each researcher in the team to have her/his own main topic. However **we organize the team in order to maximize internal collaborations**. We consider this point, which justifies the existence of Inria project-teams, as essential to the success of our programme of research. It relies on the fact that, to develop our mathematical and numerical studies, we share a common interest for collaborations with engineers, practitioners, physicists, biologists and numerical analysts, and we also share the following common toolbox:

- Stochastic differential calculus;
- Mathematical combinations of both partial differential equations (PDEs) analysis and stochastic analysis for deterministic non-linear PDEs, notably stochastic control equations and McKean-Vlasov-Fokker-Planck equations;
- Original stochastic numerical analysis techniques to get theoretical estimates on stochastic numerical methods, and numerical experiments to calibrate these methods.

We finally emphasize that the unifying theme of our research is to develop analytical tools that can be effectively applied to various problems that come from extremely diverse subjects. For example, as described in more detail below, we study: branching processes and their simulation with the view of advancing our understanding of population dynamics, molecular dynamics, and cancer models; the theory and numerical analysis of McKean-Vlasov interacting particle systems in order to develop our models in biology, computational fluid dynamics, coagulation and fragmentation; hitting times of domains by stochastic processes so that we can improve on the current methods and theory used in finance and neuroscience.

3. Research Program

3.1. Research Program

Most often physicists, economists, biologists and engineers need a stochastic model because they cannot describe the physical, economical, biological, etc., experiment under consideration with deterministic systems, either because of its complexity and/or its dimension or because precise measurements are impossible. Therefore, they abandon trying to get the exact description of the state of the system at future times given its initial conditions, and try instead to get a statistical description of the evolution of the system. For example, they desire to compute occurrence probabilities for critical events such as the overstepping of a given thresholds by financial losses or neuronal electrical potentials, or to compute the mean value of the time of occurrence of interesting events such as the fragmentation to a very small size of a large proportion of a given population of particles. By nature such problems lead to complex modelling issues: one has to choose appropriate stochastic models, which require a thorough knowledge of their qualitative properties, and then one has to calibrate them, which requires specific statistical methods to face the lack of data or the inaccuracy of these data. In addition, having chosen a family of models and computed the desired statistics, one has to evaluate the sensitivity of the results to the unavoidable model specifications. The TOSCA team, in collaboration with specialists of the relevant fields, develops theoretical studies of stochastic models, calibration procedures, and sensitivity analysis methods.

In view of the complexity of the experiments, and thus of the stochastic models, one cannot expect to use closed form solutions of simple equations in order to compute the desired statistics. Often one even has no other representation than the probabilistic definition (e.g., this is the case when one is interested in the quantiles of the probability law of the possible losses of financial portfolios). Consequently the practitioners need Monte Carlo methods combined with simulations of stochastic models. As the models cannot be simulated exactly, they also need approximation methods which can be efficiently used on computers. The TOSCA team develops mathematical studies and numerical experiments in order to determine the global accuracy and the global efficiency of such algorithms.

The simulation of stochastic processes is not motivated by stochastic models only. The stochastic differential calculus allows one to represent solutions of certain deterministic partial differential equations in terms of probability distributions of functionals of appropriate stochastic processes. For example, elliptic and parabolic linear equations are related to classical stochastic differential equations (SDEs), whereas nonlinear equations such as the Burgers and the Navier–Stokes equations are related to McKean stochastic differential equations describing the asymptotic behavior of stochastic particle systems. In view of such probabilistic representations one can get numerical approximations by using discretization methods of the stochastic differential systems under consideration. These methods may be more efficient than deterministic methods when the space dimension of the PDE is large or when the viscosity is small. The TOSCA team develops new probabilistic representations in order to propose probabilistic numerical methods for equations such as conservation law equations, kinetic equations, and nonlinear Fokker–Planck equations.

4. Application Domains

4.1. Domain

TOSCA is interested in developing stochastic models and probabilistic numerical methods. Our present motivations come from models with singular coefficients, with applications in Geophysics, Molecular Dynamics and Neurosciences; Lagrangian modeling in Fluid Dynamics and Meteorology; Population Dynamics, Evolution and Genetics; Neurosciences; and Financial Mathematics.

4.1.1. *Stochastic models with singular coefficients: Analysis and simulation*

Stochastic differential equations with discontinuous coefficients arise in Geophysics, Chemistry, Molecular Dynamics, Neurosciences, Oceanography, etc. In particular, they model changes of diffusion of fluids, or diffractions of particles, along interfaces.

For practioners in these fields, Monte Carlo methods are popular as they are easy to interpret — one follows particles — and are in general easy to set up. However, dealing with discontinuities presents many numerical and theoretical challenges. Despite its important applications, ranging from brain imaging to reservoir simulation, very few teams in mathematics worldwide are currently working in this area. The Tosca project-team has tackled related problems for several years providing rigorous approach. Based on stochastic analysis as well as interacting with researchers in other fields, we developed new theoretical and numerical approaches for extreme cases such as Markov processes whose generators are of divergence form with discontinuous diffusion coefficient.

The numerical approximation of singular stochastic processes can be combined with backward stochastic differential equations (BSDEs) or branching diffusions to obtain Monte Carlo methods for quasi-linear PDEs with discontinuous coefficients. The theory of BSDEs has been extensively developed since the 1980s, but the general assumptions for their existence can be quite restrictive. Although the probabilistic interpretation of quasi-linear PDEs with branching diffusions has been known for a long time, there have been only a few works on the related numerical methods.

Another motivation to consider stochastic dynamics in a discontinuous setting came to us from time evolution of fragmentation and coagulation phenomena, with the objective to elaborate stochastic models for the avalanche formation of soils, snow, granular materials or other geomaterials. Most of the models and numerical methods for avalanches are deterministic and involve a wide variety of physical parameters such as the density of the snow, the yield, the friction coefficient, the pressure, the basal topography, etc. One of these methods consists in studying the safety factor (or limit load) problem, related to the shallow flow of a visco-plastic fluid/solid with heterogeneous thickness over complex basal topography. The resulting nonlinear partial differential equation of this last theory involves many singularities, which motivates us to develop an alternative stochastic approach based on our past works on coagulation and fragmentation. Our approach consists in studying the evolution of the size of a typical particle in a particle system which fragments in time.

4.1.2. *Stochastic Lagrangian modeling in Computational Fluid Dynamics*

Stochastic Lagrangian models were introduced in the eighties to simulate complex turbulent flows, particularly two-phase flows. In Computational Fluid Dynamics (CFD), they are intensively used in the so-called Probability Density Functions (PDF) methods in order to model and compute the reaction-phase terms in the fundamental equations of fluid motions. The PDF methods are currently developed in various laboratories by specialists in scientific computation and physicists. However, to our knowledge, we are innovating in two ways:

- our theoretical studies are the pioneering mathematical analysis of Lagrangian stochastic models in CFD;
- our work on the Stochastic Downscaling Method (SDM) for wind simulation is the first attempt to solve the fundamental equations themselves by a fully 3D stochastic particle method.

We emphasize that our numerical analysis is essential to the SDM development which takes benefits from our deep expertise on numerical schemes for McKean-Vlasov-non-linear SDEs.

4.1.3. *Population Dynamics, Evolution and Genetics*

The activity of the team on stochastic modeling in population dynamics and genetics mainly concerns application in adaptive dynamics, a branch of evolutionary biology studying the interplay between ecology and evolution, ecological modeling, population genetics in growing populations, and stochastic control of population dynamics, with applications to cancer growth modeling. Stochastic modeling in these areas mainly considers individual-based models, where the birth and death of each individual is described. This class of model is well-developed in Biology, but their mathematical analysis is still fragmentary. Another important topic in population dynamics is the study of populations conditioned to non-extinction, and of the corresponding stationary distributions, called quasi-stationary distributions (QSD). This domain has been the object of a lot of studies since the 1960's, but we made recently significant progresses on the questions of existence, convergence and numerical approximation of QSDs using probabilistic tools rather than the usual spectral tools.

Our activity in population dynamics also involves a fully new research project on cancer modeling at the cellular level by means of branching processes. In 2010 the International Society for Protons Dynamics in Cancer was launched in order to create a critical mass of scientists engaged in research activities on Proton Dynamics in Cancer, leading to the facilitation of international collaboration and translation of research to clinical development. Actually, a new branch of research on cancer evolution is developing intensively; it aims in particular to understand the role of proteins acting on cancerous cells' acidity, their effects on glycolysis and hypoxia, and the benefits one can expect from controlling pH regulators in view of proposing new therapies.

4.1.4. Stochastic modeling in Neuroscience

It is generally accepted that many different neural processes that take place in the brain involve noise. Indeed, one typically observes experimentally underlying variability in the spiking times of an individual neuron in response to an unchanging stimulus, while a predictable overall picture emerges if one instead looks at the average spiking time over a whole group of neurons. Sources of noise that are of interest include ionic currents crossing the neural membrane, synaptic noise, and the global effect of the external environment (such as other parts of the brain).

It is likely that these stochastic components play an important role in the function of both the neurons and the networks they form. The characterization of the noise in the brain, its consequences at a functional level and its role at both a microscopic (individual neuron) level and macroscopic level (network of thousands of neurons) is therefore an important step towards understanding the nervous system.

To this end, a large amount of current research in the neuroscientific literature has involved the addition of noise to classical purely deterministic equations resulting in new phenomena being observed. The aim of the project is thus to rigorously study these new equations in order to be able to shed more light on the systems they describe.

4.1.5. Stochastic modeling in Financial Mathematics

4.1.5.1. Technical Analysis

In the financial industry, there are three main approaches to investment: the fundamental approach, where strategies are based on fundamental economic principles; the technical analysis approach, where strategies are based on past price behavior; and the mathematical approach where strategies are based on mathematical models and studies. The main advantage of technical analysis is that it avoids model specification, and thus calibration problems, misspecification risks, etc. On the other hand, technical analysis techniques have limited theoretical justifications, and therefore no one can assert that they are risk-less, or even efficient.

4.1.5.2. Financial Risks Estimation and Hedging

Popular models in financial mathematics usually assume that markets are perfectly liquid. In particular, each trader can buy or sell the amount of assets he/she wants at the same price (the "market price"). They moreover assume that the decision taken by the trader does not affect the price of the asset (the small investor assumption). In practice, the assumption of perfect liquidity is never satisfied but the error due to liquidity is generally negligible with respect to other sources of error such as model error or calibration error, etc.

Derivatives of interest rates are singular for at least two reasons: firstly the underlying (interest rate) is not directly exchangeable, and secondly the liquidity costs usually used to hedge interest rate derivatives have large variation in times.

Due to recurrent crises, the problem of risk estimation is now a crucial issue in finance. Regulations have been enforced (Basel Committee II). Most asset management software products on the markets merely provide basic measures (VaR, Tracking error, volatility) and basic risk explanation features (e.g., "top contributors" to risk, sector analysis, etc).

4.1.5.3. Energy and Carbon Markets

With the rise of renewable energy generation (from solar, wind, waves...), engineers face new challenges which heavily rely on stochastic and statistical problems.

Besides, in the context of the beginning of the second phase (the Kyoto phase) in 2008 of the European carbon market, together with the fact that French carbon tax was scheduled to come into law on Jan. 1, 2010, the year 2009 was a key year for the carbon price modeling. Our research approach adopts the point of view of the legislator and energy producers. We used both financial mathematical tools and a game theory approach. Today, with the third phase of the EU-ETS, that didn't yet start, and the report form the Cour des Comptes (October 2013) that pointed out (among many others point) the lack of mathematical modeling on such carbon market design, we continue our research in this direction.

4.1.5.4. Optimal Stopping Problems

The theory of optimal stopping is concerned with the problem of taking a decision at the best time, in order to maximise an expected reward (or minimise an expected cost). We work on the general problem of optimal stopping with random discounting and additional cost of observation.

4.1.5.5. First hitting times distributions

Diffusion hitting times are of great interest in finance (a typical example is the study of barrier options) and also in Geophysics and Neurosciences. On the one hand, analytic expressions for hitting time densities are well known and studied only in some very particular situations (essentially in Brownian contexts). On the other hand, the study of the approximation of the hitting times for stochastic differential equtions is an active area of research since very few results still are available in the literature.

5. Highlights of the Year

5.1. Highlights of the Year

5.1.1. Awards

BEST PAPER AWARD:

[54]
P. HELSON, E. TANRÉ, R. VELTZ. *A simple spiking neuron model based on stochastic STDP*, May 2017, International Conference on Mathematical Neuroscience, Poster, https://hal.archives-ouvertes.fr/hal-01652036

6. New Software and Platforms

6.1. MOC

Models Of Chemostat
KEYWORD: Simulator
FUNCTIONAL DESCRIPTION: MOC (for Models of Chemostat) is a Python simulator of four chemostat models: a mass-structured stochastic individual based model, a mass-structured integro-differential model, the Crump-Young model and a system of ordinary differential equations. This software allows to simulate one or several of those models with different parameters, to plot graphics of evolution of biomass concentration, number of bacteria and substrate concentration as well as the phase portrait, to determine the law of the extinction time of the bacterial population in case of population extinction.

- Participants: Coralie Fritsch and Fabien Campillo
- Contact: Coralie Fritsch
- URL: https://github.com/coraliefritsch/modelsOfChemostat

6.2. AWFController

Acoustic Wind Farm Controller

KEYWORDS: Matlab - Noise - Control

SCIENTIFIC DESCRIPTION: AWFController is a matlab module dedicated to a real time application that performs acoustic control of wind farms based on microphones set near surrounding housings. It computes the optimal command for each wind turbine at each time-step to fullfil the law criteria of acoustic annoyance while maximizing the electric production. It uses local weather measurements (wind speeds and directions) and wind turbines noise estimates computed by an audio source separation algorithm on the acoustic measurements.

FUNCTIONAL DESCRIPTION: Nowadays, wind farm owners have to reduce the velocity of their wind turbines to comply with the regulation on acoustic annoyance. However, the variability of perceived noise due to weather variations makes optimization hard to achieve. AWFController is developed along with an industrial project in order to improve the optimization by adapting wind turbines speeds in regards to acoustic measurements of permanent sensors. It computes optimal command from acoustic measurements and meteo data.

- Participants: Baldwin Dumortier, Emmanuel Vincent and Madalina Deaconu
- Contact: Baldwin Dumortier

7. New Results

7.1. Probabilistic numerical methods, stochastic modelling and applications

Participants: Mireille Bossy, Nicolas Champagnat, Quentin Cormier, Madalina Deaconu, Olivier Faugeras, Coralie Fritsch, Pascal Helson, Antoine Lejay, Radu Maftei, Victor Martin Lac, Hector Olivero-Quinteros, Paolo Pigato, Denis Talay, Etienne Tanré, Milica Tomašević, Denis Villemonais.

7.1.1. Published works and preprints

- M. Bossy, R. Maftei and Jean-François Jabir (National Research University Higher School of Economics, Moscow) propose and analyze the convergence of a time-discretization scheme for the motion of a particle when its instantaneous velocity is drifted by the known velocity of the carrying flow, and when the motion is taking into account the collision event with a boundary wall. We propose a symetrized version of the Euler scheme and prove a convergence of order one for the weak error. The regularity analysis of the associated Kolmogorov PDE is obtained by mixed variational and stochastic flow techniques for PDE problem with specular condition [46].

- N. Champagnat and B. Henry (IECL) studied a probabilistic approach for the Hamilton-Jacobi limit of non-local reaction-diffusion models of adaptive dynamics when mutations are small. They used a Feynman-Kac interpretation of the partial differential equation and large deviation estimates to obtain a variational characterization of the limit. They also studied in detail the case of finite phenotype space with exponentially rare mutations, where they were able to obtain uniqueness of the limit [48].

- N. Champagnat and P.-E. Jabin (Univ. Maryland) completed the study of the functional spaces in the article [18], devoted to the study of strong existence and pathwise uniqueness for stochastic differential equations (SDE) with rough coefficients, typically in Sobolev spaces.

- N. Champagnat and D. Villemonais consider, for general absorbed Markov processes, the notion of quasi-stationary distributions (QSD), which is a stationary distribution conditionally on non-absorbtion, and the associated Q-process, defined as the original Markov process conditioned to never be absorbed. They prove that, under the conditions of [5], in addition to the uniform exponential convergence of the conditional distributions to a unique QSD and the uniform exponential ergodicity of the Q-process, one also has the uniform convergence of the law of the process contionned to survival up to time T, when $T \to +\infty$. This allows them to obtain conditional ergodic theorems [22].

- N. Champagnat and D. Villemonais obtained criteria based on Lyapunov functions allowing to check the conditions of [5] which characterize the exponential uniform convergence in total variation of conditional distributions of an absorbed Markov process to a unique quasi-stationary distribution [50]. Among the various applications they give, they prove that these conditions apply to any logistic Feller diffusions in any dimension conditionned to the non extinction of all its coordinates. This question was left partly open since the first work of Cattiaux and Méléard on this topic [64].

- N. Champagnat and D. Villemonais obtained general conditions based on Foster-Lyapunov criteria ensuring the exponential convergence in total variation of the conditional distributions of an absorbed Markov process to a quasi-stationary distribution (QSD), with a speed that can depend on the initial distribution. In particular, these results provide a non-trivial subset of the domain of attraction of the minimal QSD of an absorbed process in cases where there is not uniqueness of a QSD. Similar results were only known for the very specific branching models. They also show how these criteria can be checked for a wide range of Markov processes in discrete or continuous time and in discrete or continuous state spaces. In all these cases, they improve significantly the best known results. A particularly remarkable result is the existence of a principal eigenfunction for the generator of elliptic diffusion processes aborded at the boundary of an open domain without any regularity assumption on the boundary of this domain [49].

- During his internship supervised by E. Tanré and R. Veltz (MATHNEURO Inria team), Q. Cormier studied numerically and theoretically a model of spiking neurons in interactions [51]. This model generalizes classical integrate and fire models: the neurons no more spike after hitting a deterministic threshold but spikes with a rate given as a function of the membrane potential (see e.g. [65]). He showed existence and uniqueness of the corresponding limit equation, and was able to extend those results in the case of excitatory and inhibitory neurons. He is now studying the long time behavior of the model, as part of his thesis.

- M. Deaconu and S. Herrmann studied the simulation of the hitting time of some given boundaries for Bessel processes. These problems are of great interest in many application fields as finance and neurosciences. More precisely they obtained recently a new method for the simulation of hitting times for Bessel processes with a non integer dimension. The main idea is to consider the simulation of the hitting time of Bessel processes with integer dimension and provide a new algorithm by using the additivity property of the laws of squared Bessel processes [26].

- M. Deaconu and S. Herrmann studied the Initial-Boundary Value Problem for the heat equation [25]. They construct an algorithm based on a random walk on heat balls in order to approximate the solution. Even if it represents a sophisticated generalization of the Walk on Spheres (WOS) algorithm introduced to solve the Dirichlet problem for Laplace's equation, its implementation is rather easy. The definition of the random walk is based on a particular mean value formula for the heat equation and they obtained also a probabilistic formulation of this formula. They proved convergence results for this algorithm and illustrate them by numerical examples.

- M. Deaconu, S. Herrmann and S. Maire [27] introduced a new method for the simulation of the exit time and position of a δ-dimensional Brownian motion from a domain. The main interest of this method is that it avoids splitting time schemes as well as inversion of complicated series. The idea is to use the connexion between the δ-dimensional Bessel process and the δ-dimensional Brownian motion thanks to an explicit Bessel hitting time distribution associated with a particular curved boundary. This allows to build a fast and accurate numerical scheme for approximating the hitting time.

- M. Deaconu, B. Dumortier and E. Vincent (EPI Multispeech) are working with the Venathec SAS on the acoustic control of wind farms. Wind turbine noise is often annoying for humans living in close proximity to a wind farm. Reliably estimating the intensity of wind turbine noise is a necessary step towards quantifying and reducing annoyance, but it is challenging because of the overlap with background noise sources. Current approaches involve measurements with on/off

turbine cycles and acoustic simulations, which are expensive and unreliable. This raises the problem of separating the noise of wind turbines from that of background noise sources and coping with the uncertainties associated with the source separation output. In their work they propose to assist a black-box source separation system with a model of wind turbine noise emission and propagation in a recursive Bayesian estimation framework. This new approach is validated on real data with simulated uncertainties using different nonlinear Kalman filters [38].

- M. Deaconu is working with L. Beznea and O. Lupaşcu (Bucharest, Romania) on the stochastic interpretation of rupture phenomena. They constructed a stochastic differential equation and a branching process for the fragmentation model. The main physical model involved in their study is the avalanche one and their model includes physical properties of the phenomenon. They introduced a new numerical algorithm issued from this study, which captures the fractal property of the avalanche [43].

- C. Fritsch, F. Campillo (Inria Sophia-Antipolis, MATHNEURO team) and O. Ovaskainen (Univ. Helsinki) proposed a numerical approach to determine mutant invasion fitness and evolutionary singular strategies using branching processes and integro-differential models in [31]. They illustrate this method with a mass-structured individual-based chemostat model.

- P. Helson, E. Tanré and R. Veltz (MATHNEURO Inria team), have numerically and theoretically studied a model of spiking neurons in interaction with stochastic plasticity. A slow-fast analysis enabled to split the dynamic in two inhomogeneous Markov chains: one models the slow variable, the other one the fast variable. The jump rates of the slow chain is governed by the invariant distribution of the fast one. In his PhD thesis, P. Helson has proved existence and uniqueness of solution. Simple conditions for the slow variable to be recurrent and transient are given [53].

- A. Lejay, L. Lenôtre (CMAP, École Polytechnique) and G. Pichot (Inria Paris, SERENA team) have continued their work on the simulation of processes on discontinuous media [56]. A new Monte Carlo scheme, called the exponential timestepping scheme and based on closed form expression of the resolvent, is being studied.

- A. Lejay, E. Mordecki (U. de la República, Uruguay) and S. Torres (U. de Valparaíso, Chile) have continuous their work on the estimation of the parameter of the Skew Brownian motion [57].

- A. Lejay and P. Pigato have studied the estimation of the parameter of the Oscillating Brownian motion, which is a solution of a stochastic differential equation whose diffusivity takes two values [35].

- A. Lejay have given an alternative proof of the Girsanov theorem which is based on semigroups [39].

- In [61] D. Talay and M. Tomašević propose a new type of stochastic interpretation of the parabolic-parabolic Keller-Segel systems. It involves an original type of McKean-Vlasov interaction kernel. At the particle level, each particle interacts with all the past of each other particle. At the mean-field level studied here, the McKean-Vlasov limit process interacts with all the past time marginals of its probability distribution. They prove that the one-dimensional parabolic-parabolic Keller-Segel system in the whole Euclidean space and the corresponding McKean-Vlasov stochastic differential equation are well-posed for any values of the parameters of the model.

- In collaboration with Jean-François Jabir (National Research University Higher School of Economics, Moscow) D. Talay and M. Tomašević prove the well–posedness of an original singularly interacting stochastic particle system associated to the one-dimensional parabolic-parabolic Keller-Segel model. They also establish the propagation of chaos towards this model [55].

- In [44] J. Bion-Nadal (Ecole Polytechnique) and D. Talay have introduced a Wasserstein-type distance on the set of the probability distributions of strong solutions to stochastic differential equations. This new distance is defined by restricting the set of possible coupling measures. They proved that it may also be defined by means of the value function of a stochastic control problem whose Hamilton–Jacobi–Bellman equation has a smooth solution, which allows one to deduce a

priori estimates or to obtain numerical evaluations. They have exhibited an optimal coupling measure and characterized it as a weak solution to an explicit stochastic differential equation, and they finally have described procedures to approximate this optimal coupling measure.

A notable application concerns the following modeling issue: given an exact diffusion model, how to select a simplified diffusion model within a class of admissible models under the constraint that the probability distribution of the exact model is preserved as much as possible?

- E. Tanré has worked with Patricio Orio (CINV, Chile) and Alexandre Richard (Centrale-Supelec) on the modelling and measurement of long-range dependence in neuronal spike trains. They exhibit evidence of memory effect in genuine neuronal data and compared a fractional integrate-and-fire model with the existing Markovian models (paper in revision: [60]).

- D. Villemonais worked with his Research Project student William Oçafrain (École des Mines de Nancy) on an original mean-field particle system [36]. They proved that the mean-field particle system converges in full generality toward the distribution of a conditioned Markov process, with applications to the approximation of the quasi-stationary distribution of piecewise deterministic Markov processes.

- D. Villemonais, Camille Coron (Université Paris XI) and Sylvie Méléard (École Polytechnique) proved a criterion for the integrability of paths of one-dimensional diffusion processes in [52] from which we derive new insights on allelic fixation in several situations.

- D. Villemonais obtains a lower bound for the coarse Ricci curvature of continuous time pure jump Markov processes in [62], with an emphasis on interacting particle systems. In this preprint, several models are studied, with a detailed study of the herd behavior of a simple model of interacting agents. The lower bound is shown to be sharp for birth and death processes.

7.1.2. Other works in progress

- M. Bossy, J. Fontbona (Universidad de Chile, Chile) and H. Olivero-Quinteros are working in a model for a network of neurons interacting electrically and chemically in a mean field fashion. They have proved the synchronization of the network under suitable values for the parameters of the model and a concentration result for the mean field limit.

- N. Champagnat is working with P. Vallois (IECL and Inria BIGS team) and L. Vallat (CHRU Strasbourg) on the inference of dynamical gene networks from RNAseq and proteome data.

- N. Champagnat, C. Fritsch and S. Billiard (Univ. Lille) are working on food web modeling.

- N. Champagnat, C. Fritsch and D. Villemonais are working with A. Gégout-Petit, P. Vallois, A. Mueller-Gueudin (IECL and Inria BIGS team), A. Kurtzmann (IECL), A. Harlé, J.-L. Merlin (ICL and CRAN) and E. Pencreac'h (CHRU Strasbourg) within an ITMO Cancer project on modeling and parametric estimation of dynamical models of circulating tumor DNA (ctDNA) of tumor cells, divided into resistant and sensitive ctDNA depending on whether they hold mutations known to provide resistance to a given targeted therapy or not. The goal of the project is to predict sooner and more accurately the emergence of resistance to the targeted therapy in a patient's tumor, so that the patient's therapy can be modulated more efficiently.

- M. Deaconu and S. Herrmann are working on numerical approaches for hitting times of some general stochastic differential equations.

- M. Deaconu, O. Lupaşcu and L. Beznea (Bucharest, Romania) are working on the connexion between branching processes and partial differential equations in fluid mechanics.

- M. Deaconu, B. Dumortier and E. Vincent (EPI Multispeech) are working on handling uncertainties in the wind farms model in order to design a stochastic algorithm.

- M. Deaconu and R. Stoica (Université de Lorraine, Nancy) are working on the ABC Shadow algorithm and its possible generalizations.

- O. Faugeras, E. Soret and E. Tanré are working on Mean-Field descriptions or thermodynamics limits of large populations of neurons. They study a system of EDS which describes the evolution of membrane potential of each neuron over the time when the synaptic weights are random variables (not assumed to be independent).

- O. Faugeras, James Maclaurin (Univ. of Utah) and E. Tanré have worked on the asymptotic behavior of a model of neurons in interaction with correlated gaussian synaptic weights. They have obtained the limit equation as a singular non-linear SDE and a Large Deviation Principle for the law of the finite network.

- C. Fritsch is working with A. Gégout-Petit (Univ. Lorraine and sc Bigs team), B. Marçais (INRA, Nancy) and M. Grosdidier (INRA, Nancy) on a statistical analysis of a Chalara fraxinea model.

- P. Helson, E. Tanré and R. Veltz (MATHNEURO Inria team) are working on a mathematical framework for plasticity models. The aim is to propose a 'optimized' model of memory capacity and memory lifetime.

- A. Lejay, A. Brault (Univ. Toulouse) and L. Coutin (Univ. Toulouse) are working on a non linear generalization of the sewing lemma, which is the main technical tool in the theory of rough paths.

- V. Martin Lac, H. Olivero-Quinteros and D. Talay are working on theoretical and algorithmic questions related to the simulation of large particle systems under singular interactions and to the simulation of independent random variables with heavy tails.

- C. Graham (École Polytechnique) and D. Talay are ending and polishing the second volume of their series on Mathematical Foundation of Stochastic Simulation to be published by Springer.

- P-E. Jabin (University of Maryland) and D. Talay are working on a mean-field game and developing a new technique to analyse it.

- E. Tanré is working with Nicolas Fournier (Univ. Pierre et Marie Curie, Paris 6) and Romain Veltz (MATHNEURO Inria team) on a network of spiking networks with propagation of spikes along the dendrites. Consider a large number n of neurons randomly connected. When a neuron spikes at some rate depending on its electric potential, its potential is set to a minimum value v_{min}, and this makes start, after a small delay, two fronts on the dendrites of all the neurons to which it is connected. Fronts move at constant speed. When two fronts (on the dendrite of the same neuron) collide, they annihilate. When a front hits the soma of a neuron, its potential is increased by a small value w_n. Between jumps, the potentials of the neurons are assumed to drift in $[v_{min}, \infty)$, according to some well-posed ODE. We prove the existence and uniqueness of a heuristically derived mean-field limit of the system when $n \to \infty$.

- E. Tanré is working with Alexandre Richard (Centrale-Supelec) and Soledad Torres (Universidad de Valparaíso, Chile) on a one-dimensional fractional SDE reflected on the line. The existence and uniqueness of this process is known in the case of the Hurst parameter H of the noise (fBM) is larger than 0.5. They have proved the existence of a penalization scheme (suited to numerical approximation) to approach this object. When $H \in (\frac{1}{4}, \frac{1}{2})$, they have proved the existence in the elliptic.

- D. Villemonais works in collaboration with Éliane Albuisson (CHRU of Nancy), Athanase Benetos (CHRU of Nancy), Simon Toupance (CHRU of Nancy), Daphné Germain (École des Mines de Nancy), Anne Gégout-Petit (Inria BIGS team) and Sylvain Chabanet (École des Mines de Nancy). The aim of this collaboration is to conduct a statistical study of the time evolution of telomere's length in human cells.

- D. Villemonais started a collaboration with Cécile Mailler (University of Bath) with the aim of studying the almost sure convergence of measure valued Pólya urns models.

7.2. Financial Mathematics

Participants: Madalina Deaconu, Antoine Lejay, Paolo Pigato, Khaled Salhi, Etienne Tanré.

7.2.1. Published works and preprints

- When the underlying asset price is given by a exponential Lévy model, the market is almost incomplete. Under this hypothesis, M. Deaconu, A. Lejay and K. Salhi worked on derivatives hedging under a budget constraint on the initial capital. He considers, as criterion of optimization, the CVaR of the terminal hedging risk. First, he rewrites the problem an optimisation problem on the random fraction of the payoff that permits to respect the budget constraint. Then, he approximates the problem by relaxing the constraint and considering only a specific equivalent martingale measure. This approximate problem is solved using Neyman-Pearson's Lemma and, in the case of European options, a numerical valuation of the approximated minimal CVaR based on fast Fourier transform [28].

- A. Lejay and P. Pigato studied the estimation of the coefficients of the Geometric Oscillating Brownian motion on financial data. This stochastic process is a modification of the Black & Scholes model that takes into account leverage effect and other sudden changes in the volatility [58], [41].

- V. Reutenauer and E. Tanré have worked on extensions of the exact simulation algorithm introduced by Beskos et al. [63]. They propose an unbiased algorithm to approximate the two first derivatives with respect to the initial condition x of quantities with the form $\mathbb{E}\Psi(X_T^x)$, where X is a one-dimensional diffusion process and Ψ any test-function. They also propose an efficient modification of Beskos et al. algorithm ([59], paper in revision).

8. Bilateral Contracts and Grants with Industry

8.1. Bilateral Contracts with Industry

- M. Deaconu is involved in a bilateral contract with Venathec. She is supervising, with E. Vincent (EPI Multispeech), the Ph.D. thesis of B. Dumortier on the acoustic control of wind farms noise.

8.2. Bilateral Grants with Industry

- M. Bossy is member of a MERIC project (MERIC is the marine energy research & inovation center in Chile) on stochastic Lagrangian models to better estimate energy production variability with water turbine, granted with the Lemon Inria Team.

- M. Bossy is the Coordinator of the TER project from the PGMO (FMJH) granted with the SME METIGATE, on the statistical description of coupled regional temperatures. D. Talay also participates to this project.

- M. Bossy is the Coordinator of the SPARE projet at UCA-JEDI on Monte Carlo approaches for the simulation of particles transport in a flow, with EDF and Observatoire de la Côte d'Azur.

- M. Bossy is the Coordinator of the POPART Industrial partnership projet at UCA-JEDI on the modeling of fiber transport in turbulent flow. This partnership is granted by EDF and by UCA, and in collaboration with Observatoire de la Côte d'Azur.

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. ANR

N. Champagnat is member of the ANR NONLOCAL (Phénomènes de propagation et équations non locales, 2014–2018) coordinated by F. Hamel (Univ. Aix-Marseille).

9.1.2. ITMO project

N. Champagnat, C. Fritsch and D. Villemonais are involved in an ITMO Cancer project (INSERM funding) on "Modeling ctDNA dynamics for detecting targeted therapy resistance" (2017-2020), involving researchers from IECL (Institut Elie Cartan de Lorraine), the Inria teams BIGS and TOSCA, ICL (Institut de Cancérologie de Lorraine), CRAN (Centre de Recherche en Automatique de Nancy) and CHRU Strasbourg (Centre Hospitalier Régional Universitaire). This project is coordinated by N. Champagnat.

9.2. European Initiatives

9.2.1. FP7 & H2020 Projects

Program: FP7

Project acronym: HBP

Project title: The Human Brain Project

Duration: April 2016 - March 2018 (second part)

Coordinator: EPFL

Other partners: see the webpage of the project.

Abstract: Understanding the human brain is one of the greatest challenges facing 21st century science. If we can rise to the challenge, we can gain profound insights into what makes us human, develop new treatments for brain diseases and build revolutionary new computing technologies. Today, for the first time, modern ICT has brought these goals within sight. The goal of the Human Brain Project, part of the FET Flagship Programme, is to translate this vision into reality, using ICT as a catalyst for a global collaborative effort to understand the human brain and its diseases and ultimately to emulate its computational capabilities. The Human Brain Project will last ten years and will consist of a ramp-up phase (from month 1 to month 36) and subsequent operational phases. This Grant Agreement covers the ramp-up phase. During this phase the strategic goals of the project will be to design, develop and deploy the first versions of six ICT platforms dedicated to Neuroinformatics, Brain Simulation, High Performance Computing, Medical Informatics, Neuromorphic Computing and Neurorobotics, and create a user community of research groups from within and outside the HBP, set up a European Institute for Theoretical Neuroscience, complete a set of pilot projects providing a first demonstration of the scientific value of the platforms and the Institute, develop the scientific and technological capabilities required by future versions of the platforms, implement a policy of Responsible Innovation, and a programme of transdisciplinary education, and develop a framework for collaboration that links the partners under strong scientific leadership and professional project management, providing a coherent European approach and ensuring effective alignment of regional, national and European research and programmes. The project work plan is organized in the form of thirteen subprojects, each dedicated to a specific area of activity. A significant part of the budget will be used for competitive calls to complement the collective skills of the Consortium with additional expertise.

9.3. International Initiatives

9.3.1. Inria International Partners

9.3.1.1. International Initiatives

ECOS Discrelongmem

Title: On discretization procedures in Non-Gaussian long memory processes with applications in non parametric statistics and time series analysis

International Partner (Institution - Laboratory - Researcher):

Universidad de Valparaiso (Chile) - CIMFAV – Facultad de Ingenieria

PI: E. Tanré (France), S. Torrès (Chile)

Duration: 2016 - 2018

Start year: 2016

Keywords: Approximations of non-Gaussian long-memory processes. Fractional Poisson processes (fPp). Skew Fractional Process (SfP).

9.4. International Research Visitors

9.4.1. Visits of International Scientists

- E. Mordecki (Universidad de la Reppublica, Uruguay) has been visiting Nancy for two months in February-March 2017.

9.4.1.1. Internships

- Ahmed Amine Barnicha

  Subject: Modelling avalanches

  Date: Sept. 2017 - June 2018 (research project)

  Institution: Écoles des Mines de Nancy.

- Quentin Cormier

  Subject: Study of the limit equation associated to a model of interacting neurons

  Date: May 2017 - Aug. 2017

  Institution: Université Pierre et Marie Curie.

- Djibril Gueye

  Subject: Analyse de modèles markoviens couplés pour la température régionalisée

  Date: July 2017 - Oct. 2017

  Institution: AIMS- Senegal.

- Marie Muzzolon

  Subject: Estimation sans paramètres et simulation de Monte Carlo pour les processus ponctuels marqués : lien entre les méthodes ABC et les méthodes de type gradient stochastique.

  Date: April 2017 - Sept. 2017 (research project)

  Institution: Université de Lorraine.

- Fares Omari

  Subject: Analyse de modèles markoviens couplés pour la température régionalisée

  Date: July 2017 - Oct. 2017

  Institution: ENSIIE.

- Medhi Talbi

  Subject: Optimisation de portefeuille par une approche de type champ moyen

  Date: :March 2017 - July 2018 (research project)

  Institution: École Normale Supérieure Paris-Saclay.

9.4.1.2. Research Stays Abroad

- M. Deaconu has been invited one week in February to the Institute of Mathematics of the Romanian Academy, Bucarest, by Lucian Beznea.
- C. Fritsch spent three days in Munich in June to start a collaboration with Mehdi Gharasoo (Institute of Groundwater Ecology).

- D. Talay was an invited Professor at Columbia University (New York) in June. He gave a course on ergodic diffusion processes.
- E. Tanré have spent two weeks in Valparaíso (Chile) in December within the ECOS program (PIs: E. Tanré, S. Torres), working with S. Torres (Univ. of Valparaiso).

10. Dissemination

10.1. Promoting Scientific Activities

10.1.1. Promotion of Mathematics in the industry

- M. Deaconu is involved in the Fédération Charles Hermite Forum which will be held in Nancy in January 2018.
- A. Lejay has been appointed as representative of the Agence Mathématiques et Entreprise (AMIES) for the Grand-Est Region.
- D. Talay continued to serve as a member of the Scientific Committee of the AMIES National Agency aimed to promote interactions between Mathematics and Industry.
- D. Talay continued to serve as the Vice-President of the Fondation d'Entreprise Natixis which aims to contribute to develop research in quantitative finance. He also serves as a member of the Scientific Committee of the Foundation.

10.1.2. Scientific Events Organisation

- M. Bossy co-organized the Closing workshop of the project MECASIF On reduced order methods for wind and marine current power held at Inria Sophia Antipolis, February 20-22, 2017.
- M. Bossy co-organized the Wokshop EDF-UCA : HPC and fluid flow held at Inria Sophia Antipolis, November 23 - 24, 2017.
- N. Champagnat co-organizes with Marianne Clausel (Univ. de Lorraine) the weekly Seminar of Probability and Statistics of IECL, Nancy.
- D. Talay and N. Touzi (Ecole Polytechnique) organized and chaired the conference 'PDE and Probability Methods for Interactions', Inria Sophia Antipolis, March 30-31, 2017 (https://project. inria.fr/pde2017/).
- D. Talay organized the workshop 'Singular Mckean-Vlasov Dynamics', Inria Sophia Antipolis, September 14-15, 2017.
- D. Villemonais and M. Kolb organized (Univ. of Paderborn) a workshop entitled "Quasistationary Distributions: Analysis and Simulation" at Paderborn in September 2017 (http://math.uni-paderborn. de/ag/arbeitsgruppe-wahrscheinlichkeitstheorie/forschung/konferenzen/).

10.1.3. Scientific Events Selection

10.1.3.1. Member of the Conference Program Committees

- A. Lejay is member of the conference program committees of *Journées de Probabilités 2017* (Aussois, France) and of CEMRACS 2017.
- D. Talay is serving as a member of the ICMNS 2018 Conference Program Committee.

10.1.4. Journal

10.1.4.1. Member of the Editorial Boards

- N. Champagnat serves as an Associate Editor of *Stochastic Models* and of *ESAIM: Probability & Statistics* until June.

- N. Champagnat was co-editor-in-chief with Béatrice Laurent-Bonneau (IMT Toulouse) of *ESAIM: Probability & Statistics* since June.
- A. Lejay is one of the three editors of the *Séminaire de Probabilités* and *Mathematics and Computers in Simulation* (MATCOM).
- D. Talay serves as an Associate Editor of *Stochastic Processes and their Applications*, *Probability, Uncertainty and Quantitative Risk*, *ESAIM Probability and Statistics*, *Stochastics and Dynamics*, *Journal of Scientific Computing*, *Monte Carlo Methods and Applications*, *Oxford IMA Journal of Numerical Analysis*, *SIAM Journal on Scientific Computing*, *Communications in Applied Mathematics and Computational Science*, *Éditions de l'École Polytechnique*. He also serves as Co-editor in chief of *MathematicS in Action*.

10.1.4.2. Reviewer - Reviewing Activities

- M. Deaconu wrote reviews for manuscripts submitted to *Proceedings of the London Mathematical Society*, *Journal of Computational and Applied Mathematics* and *Mathematics and Computers in Simulation*.
- C. Fritsch wrote reviews for manuscripts submitted to *Journal of Biological Systems* and *Chaos, Solitons & Fractals*.
- A. Lejay wrote reviews for *Stochastic Processes and Their Applications*, *Séminaire de probabilités*, *Annals of Applied Probability*, *Physical Review E*, *Mathematical Methods of Operations Research*, *Bulletin des Sciences Mathématiques*, *Boundary Value Problems*, *Journal of Hydrology*, *Electronic Journal of Probability*, *Quantitative Finance and Economics* and *Journal of Theoretical Probability*.
- D. Talay reported on applications to the Swiss National Science Foundation (SNSF).
- D. Talay reported on an application to the FONDECYT Program, Chile.
- D. Talay reported on applications to the Research Grants Council (RGC) of Hong Kong.
- D. Talay reported on manuscripts submitted to *Electronic. J. of Probabibility*, *SINUM*, *Annals Applied Probab.*, *J. Mathématiques Pures et Appliquées*.
- E. Tanré wrote reviews for manuscripts submitted to *European Journal of Applied Mathematics*.
- E. Tanré serves has a permanent reviewer of *Mathematical Reviews of the American Mathematical Society (MathSciNet)*.
- D. Villemonais wrote reviews for *Mathematical Reviews of the American Mathematical Society (MathSciNet)* and for manuscripts submitted to *Complexity*, *Journal of Mathematical Biology* and *Annals of Applied Probability*.

10.1.5. Invited Talks

- M. Bossy has been invited to give a talk at the Forecasting and Risk Management for Renewable Energy conference in Paris June 7-9, 2017.
- M. Bossy has been invited to give a lecture talk at the CEMRACS in Marseille July 2017.
- M. Bossy has been invited to give a seminar talk at CMA MinesParisTech, in Sophia Antipolis November 2017.
- M. Bossy gave a talk at the International Workshop on BSDEs, SPDEs, Edinburgh 2017, at the MECASIF workshop, at the workshop on PDE and Probability Methods for Interactions, at theWorkshop on singular McKean Vlasov in Sophia Antipolis.
- N. Champagnat has been invited to give talks at the conference on *Ecology and evolutionary biology, deterministic and stochastic models* in Toulouse in October, at the Conference on *Quasistationary Distributions: Analysis and Simulation* in Paderborn, Germany in September, at the Workshop on *Singular McKean-Vlasov equations and their applications* in Sophia Antipolis in September, at the *Journées Scientifiques Inria 2017* at Sophia Antipolis in June, at the *Workshop on Multi-Scale Features of Selection in Population Genetics, Eurandom* in Eindhoven, The Netherlands in March and at the *Journées EDP pour la biologie évolutives* in Avignon in March.

- N. Champagnat has been invited to give seminar talks at the *Séminaire Modélisation Mathématiques et Calcul Scientifique de l'Institut Camille Jordan* in Lyon in November, at the *Séminaire du LPMA* in Paris 6 (UPMC) in February, at the *Séminaire de statistique* in Avignon in January, at the *Séminaire de probabilités et statistique du LMV* in Versailles in January and at the *Séminaire Calcul Stochastique de l'IRMA* in Strasbourg in January.

- N. Champagnat gave a colloquium talk at the *Colloquium of the Mathematical Institute* in Mainz, Germany in February.

- N. Champagnat has been invited to give lectures at the *Workshop/School on Stochastic PDEs, Mean Field Games and Biology* (4h) at the Gran Sasso Science Institute (GSSI) in L'Aquila, Italy in September and at the *Doctoral School "New Trends in Markov Processes"* (6h) in Les Diablerets, Switzerland in March.

- M. Deaconu has been invited to give a talk at the *SIAM Conference on Control and its Applications*, 10-12 July 2017, Pittsburgh, USA.

- M. Deaconu has been invited to give a plenary talk at the *Forum des Jeunes Mathématicien-ne-s*, 22-24 November 2017, Nancy.

- M. Deaconu has been invited to give a seminar talk at the *Probability and Statistic Seminar* at the Institut de Mathématiques in Marseille, in November.

- C. Fritsch has been invited to give seminar talks in February at the probability seminars of Paul Painlevé laboratory in Lille and of Fourier Institute in Grenoble, at the meeting of the Chair *Modélisation Mathématique et Biodiversité* in the VEOLIA head office in Aubervilliers and in *MaIAGE seminar* of INRA in Jouy-en-Josas. She has also been invited to give talk at the annual *ModStatSAP* day in Paris in March and at the *HELENA seminar* of the Institute of Groundwater Ecology in Munich and at the *IRMAR probability seminar* in Rennes in June.

- C. Fritsch gave a talk at the conference *Mathematical Models in Ecology and Evolution* in London in July.

- P. Helson gave a talk at the workshop *Computational Neuroscience and Optical Dynamics* in Sophia-Antipolis in May.

- P. Helson presented a poster at the conference *International Conference on Mathematical Neuroscience* in Boulder (US) in June.

- A. Lejay gave a seminar talk at the *Séminaire EDP de l'Institut Élie Cartan de Lorraine* (Metz, France) in April 2017.

- A. Lejay gave talks at the national conference *Brownian motion in cones: algebraic and analytic approaches* at Toulouse in November and at the national conference *Journées de Probabilités 2017* at Aussois in June.

- A. Lejay gave a talk at the international conference *PDE & Probability Methods for Interactions* at Sophia-Antipolis, February 2013; *Monte Carlo Methods and Applications (MCM 2017)* at Montréal in July 2017; *Scicade 2017* at Bath in September 2017; *Rough Paths in Toulouse* at Toulouse in October 2017.

- P. Pigato has been invited to give seminar talks in January, at the Probability and Statistics Seminar of Laboratoire Jean Kuntzmann (Grenoble) and at the Seminar Modern Methods in Applied Stochastics and Nonparametric Statistics of WIAS Berlin.

- In January, Paolo Pigato has given a seminar talk at the Probability and Statistic Seminar of Institut Elie Cartan (Nancy).

- P. Pigato was invited to participate, from February 26th to March 4th, to the meeting "Mathematics of Quantitative Finance" in Oberwolfach, Germany.

- D. Talay gave a lecture at the workshop *Stochastic Differential Equations: Regularity and Numerical Analysis in Finite and Infinite Dimensions*, Mathematisches Forschungsinstitut Oberwolfach, February 5-11.

- D. Talay gave an invited conference at the Moscow National Research University Higher School of Economics, Laboratory of Stochastic Analysis winter meeting, December 4-7.
- D. Talay gave a seminar at Ecole Polytechnique on October 17th.
- E. Tanré gave talks at Université du Maine and Université de Savoie.
- E. Tanré was invited in Edinburg to give a talk at the International Workshop on BSDEs, SPDEs and their Applications in the McKean-Vlasov special session (July).
- E. Tanré was invited to give a talk at the workshop PDE/Probability Interactions: Kinetic Equations, Long time and Propagation of Chaos (Luminy, September).
- D. Villemonais has been invited to give seminar talks at the Stochastic Analysis Seminar of Imperial College (London, UK), at the Séminaire de probabilités of Université de Lille, at the Séminaire de probabilités of Université de Rennes and at the Probability laboratory of the Univeristy of Bath (UK).

10.1.6. Leadership within the Scientific Community

- M. Bossy is serving as a vice president of the Inria Evaluation Committee.
- A. Lejay is the head of the Probability and Statistics team of the Institut Élie Cartan since September 2016.
- A. Lejay is member of the Conseil de Perfectionnement of the Master of Mathematics of the Université de Lorraine.
- D. Talay continued to chair the Scientific Council of the French Applied Math. Society SMAI.
- D. Talay served as a member of the scientific council of the Complex System academy of the UCA Idex.
- D. Talay is serving as a member of the committee in charge of preparing the application of Paris to the International Congress of Mathematicians 2022.
- D. Talay is serving as a member of the CMUP Advisory Commission (University of Porto).
- D. Talay is a member of the Comité National Français de Mathématiciens.

10.1.7. Scientific Expertise

- M. Bossy reported for the Paul Caseau Prize.
- M. Bossy participated in a Associated Professor position recruitment committee at CMA Mines-ParisTech.
- N. Champagnat reported on an research project submitted to the Natural Sciences and Engineering Research Council (NSERC) of Canada.
- M. Deaconu has been a member of the *Committee for junior permanent research positions* of Inria Nancy - Grand Est.
- A. Lejay participated in a Professor position recruitment committee at Université de Lorraine.
- E. Tanré was member of the hiring committee 26 MCF at the 'Ecole Centrale de Paris'.
- E. Tanré reported on an application submitted to CONICYT (Chilean Funding Agency).
- D. Talay served as a member of the committee for positions in Applied Mathematics at the Ecole Polytechnique.
- D. Talay served as a member of the committee for a professor position at UCA University (Nice, France).
- D. Talay served as a member of the committee for an assistant professor position at Lille University.
- D. Talay is chairing the 2019 Pionneer ICIAM prize committee.

10.1.8. Research Administration

- M. Bossy has been a member of the DTK-Committee.

- N. Champagnat is a member of the *Comité de Centre*, the *COMIPERS* and the *Commission Information Scientifique et Technique* of Inria Nancy - Grand Est, *Responsable Scientifique* for the library of Mathematics of the IECL, member of the *Conseil du laboratoire* of IECL (as *responsable scientifique* of the library). He is local correspondent of the COERLE (*Comité Opérationel d'Évaluation des Risques Légaux et Éthiques*) for the Inria Research Center of Nancy - Grand Est. He is also local responsible of GdR MAMOVI for Univ. Lorraine.

- M. Deaconu is a member of the *Bureau du Comité de Projets* of Inria Nancy - Grand Est, and of the *Comité de Projet* of Inria Nancy - Grand Est.

- A. Lejay is member of the Pôle AM2I of the Université de Lorraine since 2017.

- A. Lejay is member of the theses committee of the Institut Élie Cartan de Loraine.

10.2. Teaching - Supervision - Juries

10.2.1. Teaching

Master : M. Bossy, *Risk on energetic financial markets*, 27h, Master Spécialisé, Ingénierie et Gestion de l'Énergie, Mine ParisTech, France.

Master : M. Bossy *Stochastic Particle Methods for PDEs*, 18h, M2 Probabilité et Applications, Université Pierre et Marie Curie, France.

Master: N. Champagnat, *Introduction to Quantitative Finance*, 18h, M1, École des Mines de Nancy, France.

Master: N. Champagnat, *Introduction to Quantitative Finance*, 13.5h, M2, École des Mines de Nancy, France.

PhD-level lecture: N. Champagnat, *Large population scalings of stochastic population dynamics in ecology and evolution*, Workshop/School on Stochastic PDEs, Mean Field Games and Biology, 6h, at the Gran Sasso Science Institute (GSSI) in L'Aquila (Italy).

PhD-level lecture: N. Champagnat, *Quasi-Stationary Distributions for absorbed Markov processes*, Doctoral School on *New trends in Markov Processes*, 9h, Les Diablerets (Switzerland).

Master: M. Deaconu, *Équations différentielles stochastiques : résolution numérique et applications*, 21h, M2, École des Mines de Nancy, France.

Master: M. Deaconu, *Modélisation stochastique*, 30h, M2, Université de Lorraine, France.

Master: M. Deaconu, *Simulation Monte Carlo*, 24h, M1, Faculté de Droit, Sciences Economiques et Gestion, Université de Lorraine, France.

Master : C. Fritsch, supervision of a research project on the *approximation of birth-death processes by stochastic differential equations*, 6h, M2, École des Mines de Nancy, France.

Master: A. Lejay, *Simulation des marchés financiers*, 28.5h, M2, Université de Lorraine (Metz), France.

Master: K. Salhi, *Statistiques et analyse de données*, 48h, M1, Télécom Nancy, France.

Master: K. Salhi, *Probabilité et Statistiques*, 48h, M1,ENSEM Nancy, France.

Licence: K. Salhi, *Probabilité et mathématiques financières*, 40h, L1, IUT Charlemagne, France.

Master: D. Talay *Invariant measures of diffusion processes*, 18h, M2 Probabilité et Applications, Université Paris 6, France.

Master: E. Tanré (courses) and M. Tomasevic (exercices), *Advanced Numerics for Computational Finance*, 30h (20h + 10h), M2, UCA (Mathmods Erasmus Mundus), France.

Master: E. Tanré, *Mathematical Methods for Neurosciences*, 37h, M2, ENS - Master MVA / Paris 6 - Master Maths-Bio, France.

Master: E. Tanré (courses) and M. Tomasevic (practical classes) *Numerical probability for mathematical finance*, 20h (8h + 12h), M2, EPU (Master IMAFA), France.

10.2.2. Supervision

PhD in progress: Antoine Brault, *Non-Linear Sewing Lemma*, Université Toulouse 3, October 2015, L. Coutin (U. Toulouse 3), A. Lejay.

PhD in progress: Lorenzo Campana, *Stochastic modeling of non-spherical particle transport and deposition by turbulent flows*, December 2017, M. Bossy.

PhD in progress: Quentin Cormier, *Biological Networks of Spiking Neurons*, September 2017, E. Tanré and R. Veltz (MATHNEURO Inria team).

PhD in progress: Pascal Helson, *Plasticity in networks of spiking neurons in interaction*, October 2016, E. Tanré and R. Veltz (MATHNEURO Inria team).

PhD: Radu Maftei, *Stochastic Analysis of Lagrangian Particle Simulation Application to colloidal particle collision*, Univ. Nice Sophia Antipolis, December 2017, M. Bossy.

PhD: Hernan Mardones, *Numerical solutions of stochastic differential equations with multiplicative noise*, Université de Concepción (Chile), June 2017, C. Mora (U. Concepción), A. Lejay.

PhD in progress: Milica Tomašević, *On a stochastic interpretation of parabolic-parabolic Keller-Segel systems*, October 2016, D. Talay.

10.2.3. Juries

- M. Bossy served as a referee for the Ph.D. theses of Gerome Faure *Stochastic Lagrangian models to better estimate energy production variability*.

- M. Bossy served as an examiner for the HDR of Ahmed Kebaier *Methodes Multilevel Monte Carlo et Statistiques des Processus en Finance*, Université Paris 13, December 2017.

- N. Champagnat served as a referee for the Ph.D. theses of Brice Samegni-Kepgnou, *Grandes Déviations de systèmes stochastiques modélisant des épidémies*, Aix-Marseille Univ., July 13, 2017, and of Nils Caillerie, *Équations cinétiques stochastiques et déterministes dans le contexte des mathématiques appliquées à la biologie*, Univ. Lyon 1, July 5, 2017.

- N. Champagnat served as an examiner for the Ph.D. thesis of Manon Baudel, *Théorie spectrale pour des applications de Poincaré aléatoires*, Univ. Orléans, December 1, 2017.

- M. Deaconu served as a referee for the Ph.D. thesis of Alizée Geeraert, *Contrôle optimal stochastique des processus de Markov déterministes par morceaux et application à l'optimisation de maintenance*, Université de Bordeaux, June 6, 2017.

- A. Lejay served as referee for the Ph.D. thesis of Yi Lu, *Calcul fonctionnel non-anticipatif et applications aux processus stochastiques*, Université Paris 6, December 2017.

- A. Lejay served as an examiner for the jury of Hernan Mardones, *Numerical solutions of stochastic differential equations with multiplicative noise*, Université de Concepción (Chile) in June 2017.

- A. Lejay served as a referee for the Habilitation thesis of Ahmed Kebaier, *Méthodes Multilevel Monte Carlo et Statistiques des Processus en Finance*, Université Paris 13, December 2017.

- D. Talay served as a referee for the Ph.D. thesis of Liping Xu, *Contribution à l'étude de l'équation de Boltzmann homogène*, Université Pierre et Marie Curie, June 2017.

- D. Talay served as a referee for the Habilitation thesis of Jérôme Lelong, *Quelques contributions aux méthodes numériques probabilistes et à la modélisation stochastique*, Université Grenoble Alpes, September 2017.

- D. Talay served as a referee for the Habilitation thesis of Noufel Frikha, *Stochastic approximation, Markovian perturbation of stochastic processes and their applications*, University Paris-Diderot, November 2017.

- D. Talay served as an examiner for the Habilitation thesis of Xialou Tan, *Martingale optimal transport, non Markovian stochastic control and branching diffusion processes*, December 2017.

- D. Talay served as a referee for the Ph.D. thesis of Guillaume Sall, *Quelques algorithmes rapides pour la finance quantitative*, Sorbonne Universités, December 2017.

11. Bibliography

Major publications by the team in recent years

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[3] M. BOSSY, N. MAÏZI, O. POURTALLIER. *Game theory analysis for carbon auction market through electricity market coupling*, in "Commodities, Energy and Environmental Finance", M. LUDKOVSKI, R. SIRCAR, R. AID (editors), Fields Institute Communications, Springer, 2015, vol. 74, pp. 335-370 [*DOI : 10.1007/978-1-4939-2733-3_13*], https://hal-mines-paristech.archives-ouvertes.fr/hal-01162832

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Publications of the year

Doctoral Dissertations and Habilitation Theses

[12] R. MAFTEI. *Stochastic Analysis for Lagrangian Particles Simulation*, Université Côte D'Azur ; Ecole Doctorale n°364 « Sciences Fondamentales et Appliquées », January 2017, https://hal.archives-ouvertes.fr/tel-01681293

[13] V. REUTENAUER. *Stochastic algorithms for risk management and indexing of database media*, Université Côte d'Azur, March 2017, https://tel.archives-ouvertes.fr/tel-01544854

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Scientific Books (or Scientific Book chapters)

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Research Reports

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Other Publications

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P. HELSON, E. TANRÉ, R. VELTZ. *A simple spiking neuron model based on stochastic STDP*, May 2017, International Conference on Mathematical Neuroscience, Poster, https://hal.archives-ouvertes.fr/hal-01652036.

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