IN PARTNERSHIP WITH:
CNRS
Université de Lorraine

Activity Report 2015

Project-Team TOSCA

TO Simulate and CAlibrate stochastic models

IN COLLABORATION WITH: Institut Elie Cartan de Lorraine (IECL)

RESEARCH CENTERS
Sophia Antipolis - Méditerranée
Nancy - Grand Est

THEME
Stochastic approaches

Table of contents

Project-Team TOSCA

Creation of the Project-Team: 2007 January 01

Keywords:

Computer Science and Digital Science:

6.1.2. - Stochastic Modeling (SPDE, SDE)
6.1.3. - Discrete Modeling (multi-agent, people centered)
6.1.4. - Multiscale modeling
6.2.2. - Numerical probability
6.2.3. - Probabilistic methods
6.2.4. - Statistical methods
6.4.2. - Stochastic control

Other Research Topics and Application Domains:

1.1.10. - Mathematical biology
1.1.8. - Evolutionnary biology
1.2. - Ecology
1.3.1. - Understanding and simulation of the brain and the nervous system
3.2. - Climate and meteorology
3.3.4. - Atmosphere
4.2.2. - Hydro-energy
4.2.3. - Wind energy
9.4.2. - Mathematics
9.9.1. - Environmental risks
9.9.2. - Financial risks

1. Members

Research Scientists

Denis Talay [Team leader, Inria, Senior Researcher, Sophia Antipolis - Méditerranée, HdR]
Madalina Deaconu [Deputy leader, Inria, Researcher, Nancy - Grand Est, HdR]
Mireille Bossy [Inria, Senior Researcher, Sophia Antipolis - Méditerranée, HdR]
Nicolas Champagnat [Inria, Researcher, Nancy - Grand Est, HdR]
James Inglis [Inria, Starting Research position, until July 2015, Sophia Antipolis - Méditerranée]
Antoine Lejay [Inria, Senior Researcher, Nancy - Grand Est, HdR]
Etienne Tanré [Inria, Researcher, Sophia Antipolis - Méditerranée]

Faculty Member

Denis Villemonais [Univ. Lorraine, Associate Professor, Nancy - Grand Est]

Engineer

Sélim Kraria [Inria, until May 2015, Sophia Antipolis - Méditerranée]

PhD Students

Maxime Bonelli [Koris International, CIFRE, Sophia Antipolis - Méditerranée]
Benoît Henry [Univ. Lorraine, Nancy - Grand Est]
Radu Maftei [Univ. Nice, Sophia Antipolis - Méditerranée]
Khaled Salhi [Univ. Lorraine, Nancy - Grand Est]

Milica Tomasevic [Inria, from Oct. 2015, Sophia Antipolis - Méditerranée]

Post-Doctoral Fellows

Coralie Fritsch [Inria, Nancy - Grand Est]
Oana-Valeria Lupascu [Inria, until Apr. 2015, Nancy - Grand Est]
Paolo Pigato [Inria, from Nov. 2015, Nancy - Grand Est]
Alexandre Richard [Inria, Sophia Antipolis - Méditerranée]

Visiting Scientists

Philip Protter [Columbia Univ., in Jun. 2015, Sophia Antipolis - Méditerranée]
Samuel Herrmann [Univ. Bourgogne, Professor, Nancy - Grand Est, HdR]
Jean-François Jabir [University of Valparaíso, until March and in Sep. and Oct., Sophia Antipolis - Méditerranée]
Sylvain Maire [Univ. Toulon, Associate Professor, Sophia Antipolis - Méditerranée]
Nadia Maïzi [ENSM Paris, Sophia Antipolis - Méditerranée]

Administrative Assistants

Laurence Benini [Inria, Nancy - Grand Est]
Christine Faber [Inria, Sophia Antipolis - Méditerranée]

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. Application Domains

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 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

- M. Deaconu, B. Dumortier and E. Vincent won a poster award price (http://www.ewea.org/annual2015/conference/programme/ and http://www.inria.fr/centre/nancy/actualites/ewea-2015-baldwin-dumortier-recoit-un-prix-d-honneur) for their work with the Venathec SAS on the acoustic control of wind farms.

6. New Software and Platforms

6.1. ExitBM

FUNCTIONAL DESCRIPTION

The ExitBM library provides methods to simulate random variables related to the first exit time and position of the Brownian motion from simple domains, namely intervals, squares and rectangles. This is a new software of 2015.

- Participants: Madalina Deaconu and Antoine Lejay
- Contact: Antoine Lejay
- URL: http://exitbm.gforge.inria.fr/

6.2. SDM

Stochastic Downscaling Method
FUNCTIONAL DESCRIPTION

The computation of the wind at small scale and the estimation of its uncertainties is of particular importance for applications such as wind energy resource estimation. To this aim, we have developed a computer code belonging to the family of codes of atmospheric flow calculation, in the atmospheric boundary layer. SDM especially concerns the simulation of wind at small space scales (meaning that the horizontal resolution is one kilometer or less), based on the combination of an existing Numerical Weather Prediction model providing a coarse prediction, and a Lagrangian Stochastic Model for turbulent flows.

This year we added to SDM a software tool for Configuration Interface and Visualization (CIV) of the SDM simulations. This dedicated GUI restitutes the 3D simulation view of all SDM outputs (including the rendering of interactions with mills). It is also a key environment tool to visualize a coarse resolution input, to extract time boundary condition of any chosen subdomain simulation for a NetCDF (Network Common DataForm) input file, to prepare the compilation procedure of any simulation case of SDM, to execute codes.

- Participants: Mireille Bossy, Sélim Kraria
- Contact: Mireille Bossy
- URL: http://windpos.inria.fr

6.3. Triton

KEYWORDS: Image analysis - Oceanography
FUNCTIONAL DESCRIPTION

The Triton software aims at providing a toolbox to analyze nearshore waves images recorded by a camera on the beach. More precisely, it aims at estimating the height, length and speed of waves, to find speed and direction of currents, and to reconstruct the bathymetry from these images. This is a new software of 2015.

- Participants: Stanislas Larnier, Rafael Almar and Antoine Lejay
- Contact: Antoine Lejay

7. New Results

7.1. Probabilistic numerical methods, stochastic modelling and applications

Participants: Mireille Bossy, Nicolas Champagnat, Madalina Deaconu, Coralie Fritsch, Benoît Henry, James Inglis, Antoine Lejay, Oana-Valeria Lupascu, Sylvain Maire, Paolo Pigato, Alexandre Richard, Denis Talay, Etienne Tanré, Denis Villemonais.

7.1.1. Published works and preprints

- M. Bossy with H. Quinteros (UChile) submitted a paper [36] on the strong convergence of the symmetrized Milstein scheme for some CEV-like SDEs.
- M. Bossy and J.-F. Jabir (University of Valparaíso) submitted a paper [35] on the particle approximation for Lagrangian stochastic models with specular boundary condition.
- M. Bossy with N. Maizi (Mines ParisTech) and O. Pourtallier (Inria) published a book chapter [31] on game theory analysis for carbon auction market through electricity market coupling hypothesis.
- M. Bossy, O. Faugeras (Inria Sophia, EPI NEUROMATHCOMP), and D. Talay published a clarification on the well-posedness of the limit equations to the mean-field N-neuron models proposed in [58] and proven the associated propagation of chaos property. They also have completed the modeling issue in [58] by discussing the well-posedness of the stochastic differential equations which govern the behavior of the ion channels and the amount of available neurotransmitters. See [15].
- M. Bossy, N. Champagnat, S. Maire and L. Violeau worked with H. Leman (CMAP, Ecole Polytechnique) and M. Yvinec (Inria Sophia, GEOMETRICA team) on Monte Carlo methods for the linear and non-linear Poisson-Boltzmann equations [14]. These methods are based on walk on spheres algorithm, simulation of diffusion processes driven by their local time, and branching Brownian motion to deal with the nonlinear case.
- Together with M. Baar and A. Bovier (Univ. Bonn), N. Champagnat studied the adaptive dynamics of populations under the assumptions of large population, rare and small mutations [34]. In this work, the three limits are taken simultaneously, contrary to the classical approach, where the limits of large population and rare mutations are taken first, and next the limit of small mutations [59]. We therefore obtain the precise range of assumptions under which these limits can be taken, and provide explicit biological conditions for which our approximation is valid.
- N. Champagnat and C. Fritsch worked with F. Campillo (Inria Sophia-Antipolis, LEMON team) on the links between a branching process and an integro-differential equation of a growth-fragmentation-death model [37]. They proved that the two representations of the model lead to the same criteria of invasion of a population in a given environment.
- Using a new method to compute the expectation of an integral with respect to a random measure, N. Champagnat and B. Henry obtained explicit formulas for the moments of the frequency spectrum in the general branching processes known as Splitting Trees, with neutral mutations and under the infinitely-many alleles model [40]. This allows them to obtain a law of large numbers for the frequency spectrum in the limit of large time.
- N. Champagnat and P.-E. Jabin (Univ. Maryland) improved significantly the description of the functional spaces in the preprint [41], 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 obtained criteria for existence and uniqueness of quasi-stationary distributions (QSD) and Q-processes for general absorbed Markov processes [17]. A QSD is a stationary distribution conditionally on non-absorbtion, and the Q-process is defined as the original Markov process conditioned to never be absorbed. The criteria ensure exponential convergence of the t-marginal of the process conditioned not to be absorbed at time t, to the QSD and also the exponential ergodicity of the Q-process.

- N. Champagnat and D. Villemonais obtained criteria for existence, uniqueness and exponential convergence in total variation to QSD for general absorbed and killed diffusion processes [43], [42]. For diffusions without killing [43], the criterion obtained is equivalent to the property that a diffusion on natural scale coming down from infinity has uniformly (w.r.t. the initial condition) bounded expectation at a fixed time t. The criteria obtained for diffusion processes with killing on $[0, \infty)$ [42] combine the last criteria and conditions on the killing time only close to 0, provided ∞ is an entrance boundary.
- N. Champagnat and D. Villemonais obtained criteria for existence, uniqueness and exponential convergence in total variation to QSD for general multi-dimensional birth and death processes in $\mathbb{Z}_+^d$ absorbed at the boundary $\mathbb{Z}_+^d \setminus \mathbb{N}^d$ [44]. These birth and death models are motivated by population dynamics and the criteria obtained assume stronger intra-spectific competition than inter-specific competition. These resuls are the first one for such processes, except for the particular case of branching processes, which can be studied using very specific methods.
- M. Deaconu, S. Herrmann and S. Maire introduced a new method for the simulation of the exit time and position of a δ-dimensional Brownian motion from a domain. This method is based on 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 brownian hitting time [19].
- M. Deaconu and O. Lupaşcu worked with L. Beznea (Bucharest, Romania) on the probabilistic interpretation of fragmentation phenomena. They constructed a continuous time branching process and characterized its behavior by using new potential theoretical tools [12].
- M. Deaconu, O. Lupaşcu and L. Beznea (Bucharest, Romania) started a new challenging work on the description of rupture phenomena like avalanches, by using fragmentation models. The physical properties of the model are deeply involved in this study. The first results concern a stochastic equation of fragmentation and branching processes related to avalanches [13].
- M. Deaconu, B. Dumortier and E. Vincent are working with the Venathec SAS on the acoustic control of wind farms. They constructed a new approach to control wind farms with a control model based on real-time source separation. They first designed a deterministic algorithm in order to maximize the electric production of the wind farms under the legal acoustic constraints. They showed that it is a non linear knapsack optimization problem and they proposed an efficient solution in that context using a branch and bound algorithm based on continuous relaxation. This work was published at the EWEA 2015 [30].
- In [49], B. Henry showed a central limit theorem for the population counting process of a supercritical Splitting Tree in the limit of large time. Thanks to the results of [40], he also obtained a central limit theorem for the frequency spectrum of Splitting Trees with neutral mutations and under the infinitely-many alleles model.
- S. Herrmann and E. Tanré have proposed a new very efficient algorithm to simulate the first-passage-time of a one-dimensional Brownian motion over a continuous curved boundary [23].
- J. Inglis and E. Tanré together with F. Delarue and S. Rubenthaler (Univ. Nice – Sophia Antipolis) completed their study of the mean-field convergence of a highly discontinuous particle system modeling the behavior of a spiking network of neurons [21].
- In collaboration with J. Maclaurin (Inria Sophia, EPI NEUROMATHCOMP) J. Inglis has presented a general framework to rigorously study the effect of spatio-temporal noise on traveling waves and stationary patterns. In particular the framework can incorporate versions of the stochastic neural field equation that may exhibit traveling fronts, pulses or stationary patterns. They have formulated a local SDE that describes the position of the stochastic wave up until a discontinuity time, at which point the position of the wave may jump and studied the local stability of this stochastic front and the long-time behavior of the stochastic wave [50].

- A. Lejay has continued his work on the Snapping Out Brownian motion, especially with regard to the simulation issues, with potential application to brain imaging techniques [33], [53].
- A. Lejay has continued his work on the simulation of processes with either discontinuous drift (with Arturo Kohatsu-Higa, Ritsumeikan Universitey and Kazuhiro Yasuda, Hosei University, Japan) [52] or with discontinuous coefficients (with Lionel Lenêtre and Géraldine Pichot, EPI SAGE, Irisa) [54].
- A. Lejay has continued his work on the theory of rough paths, notably with the sensitivity aspects with Laure Coutin (Univ. Toulouse III) [47].
- In collaboration with Ivan Dimov and Jean-Michel Sellier (BAS), S. Maire developed a new Monte Carlo method, called the walk on equations, to solve linear systems of equations [22].
- In collaboration with Xuan Vu, Caroline Chaux-Moulin and Nadege Thirion-Moreau, S. Maire developed a stochastic algorithm to decompose large non-negative tensors with applications in spectroscopy [28].
- In collaboration with Martin Simon, Sylvain Maire developed a variant of the walk on spheres method to deal with diffusion equations appearing in electrical impedance tomography.
- With Giang Nguyen, Sylvain Maire worked on finite differences techniques to deal with many kinds of boundary conditions that are met during the Monte Carlo simulation of diffusions [25].
- A. Richard submitted a paper [56] on the spectral representation of L^2-indexed increment-stationary processes. The main result states that any random field (i.e. process indexed by a multidimensional parameter of a function in L^2) with stationary increments can be written as an integral against a random measure satisfying certain properties. Applications to sample path properties of a multiparameter fractional Brownian motion are exhibited.
- D. Villemonais worked with P. Del Moral (Univ. Sydney) on the conditional ergodicity of time inhomogeneous diffusion processes [48]. They proved that, conditionally on non extinction, an elliptic time-inhomogeneous diffusion process forgets its initial distribution exponentially fast. An interacting particle scheme to numerically approximate the conditional distribution is also provided.
- D. Villemonais proved a Foster-Lyapunov type criterion which ensures the α-positive recurrence of birth and death processes. This criterion also provides a non-trivial subset of the domain of attraction for quasi-stationary distributions. Finally, this study leads to a Foster-Lyapunov type criterion which ensures the exponential ergodicity of a Fleming-Viot type particle system whose particles evolve as birth and death processes. The criterion also ensures the tightness of the sequence of empirical stationary distributions considered as a family of random measures. A numerical study of the speed of convergence of the particle system is also obtained under various settings [29].
- J. Inglis and D. Talay ended their work on mean-field limits of a stochastic particle system smoothly interacting through threshold hitting-times and applications to neural networks with dendritic component [51].

7.1.2. Other works in progress

- Together with M. Andrade (Univ. Paris 7) and R. Ferrière (ENS Paris and Univ. Arizona), N. Champagnat is working on the phenomenon of clustering in populations structured by space and traits for which local adaptation favors different trait values at different spatial locations. Two methods are used and numerically validated: a Turing instablity method and a Hamilton-Jacobi approximation of the population density. This work is currently being written.
- N. Champagnat and J. Claisse (Ecole Polytechnique) are currently working on the ergodic and infinite horizon controls of discrete population dynamics with almost sure extinction in finite time. This can either correspond to control problems in favor of survival or of extinction, depending on the cost function. They have proved that these two problems are related to the QSD of the processes controled by Markov controls. This work is currently being written.

- N. Champagnat and C. Fritsch worked with F. Campillo (Inria Sophia-Antipolis, LEMON team) on the variations of the principal eigenvalue (resp. the survival probability) of an integro-differential equation (resp. branching process) of growth-fragmentation-death models with respect to an environmental parameter. This work is currently being written.
- N. Champagnat, K. Coulibaly-Pasquier (Univ. Lorraine) and D. Villemonais are currently working on general criteria for existence, uniqueness and exponential convergence in total variation to QSD for multi-dimensional diffusions in a domain absorbed at its boundary. These results both improve and simplify the existing results and methods. This work is currently being written.
- N. Champagnat and D. Villemonais are currently working on extensions of their work [17] to general penalized processes, including time-inhomogeneous Markov processes with absorption. Their method allows to improve significantly the former results of [60], [61]. This work is currently being written.
- N. Champagnat and D. Villemonais are also working on extensions of the criteria of [17] in the form of Foster-Lyapunov criteria allowing to deal with cases where the convergence of conditional distribution to the QSD is not uniform with respect to the initial distribution. This work is currently being written.
- M. Deaconu and S. Herrmann are working on the numerical approach of the time-space Dirichlet problem.
- M. Deaconu, O. Lupaşcu and L. Beznea (Bucharest, Romania) worked on the numerical scheme for the simulation of an avalanche by using the fragmentation model. This work is currently being written.
- M. Deaconu, B. Dumortier and E. Vincent are working with the Venathec SAS on the acoustic control of wind farms. They plan to submit another article to IEEE transaction on sustainable energy soon. Currently they work on handling uncertainties in the model in order to design a stochastic algorithm.
- C. Fritsch worked with F. Campillo (Inria Sophia-Antipolis, LEMON team) and O. Ovaskainen (Univ. Helsinki) about the numerical analysis of the invasion of mutant populations in a chemostat, using branching processes and integro-differential models.
- C. Fritsch started a collaboration with B. Cloez (INRA, Montpellier) on a central limit theorem of mass-structured individual-based chemostat model.
- With P. Pigato, A. Lejay has continued his work on the estimation of parameters of skew diffusions.
- Within the ANESTOC Associate Team, R. Rebolledo (Pontificia Universidad Católica de Chile) and A. Richard initiated a work on the long-term behavior of a class of non-Markovian stochastic differential equations. These equations of Volterra type can be used to model the motion of a particle subject to friction forces in a heat bath, which could also be interesting in neuroscience for ion channels.
- A. Richard and E. Tanré are working with P. Orio (CINV, Chile) on the measurement of long-range dependence in series of neuronal spikes, and are providing a leaky integrate-and-fire model with fractional noise to include this effect. So far, we produced numerical experiments that confirm the existence of memory in our model, and A. Richard and E. Tanré now work on the convergence of the statistical estimator that measures this phenomenon.
- A. Richard, E. Tanré and S. Torres (Universidad de Valparaíso, Chile) are working on the definition of a skew fractional Brownian motion. The skew Brownian motion (sBm) is a process which is partly reflected when it reaches the horizontal line, making it a natural model for the motion of a particle crossing media with different diffusion properties. The fractional sBm is a modification of this process to incorporate long-range dependences. So far, we constructed a reflected fractional Brownian motion, and we are now investigating its approximation by a discrete-time process.

- During her internship supervised by E. Tanré and Romain Veltz (NEUROMATHCOMP team), Roberta Evangelista worked on “A stochastic model of gamma phase modulated orientation selectivity”. Neurons in primary visual cortex (V1) are known to be highly selective for stimulus orientation. Recent experimental evidence has shown that, in awake monkeys, the orientation selectivity of V1 neurons is modulated by gamma oscillations. In particular, neurons’ firing rate in response to the preferred orientation changes as a function of the gamma phase of spiking. The effect is drastically reduced for non-preferred orientations. We have introduced a stochastic model of a network of orientation-dependent excitatory and inhibitory spiking neurons. We have found conditions on the parameters such that the solutions of the mathematical model reproduce the experimental behavior.
- During his internship supervised by E. Tanré and Romain Veltz (NEUROMATHCOMP team), Quentin Cormier studies numerically and theoretically a model of spiking neuron in interaction with plasticity. The synaptic weights evolve according to biological law of plasticity. We study the existence of separable time scales. During his internship, Quentin Cormier also develop a numerical code to simulate large networks of neurons evolving according to this dynamics.
- C. Graham (Ecole Polytechnique) and D. Talay have written a large part of the second volume of their series on Mathematical Foundation of Stochastic Simulation.

7.2. Financial Mathematics

Participants: Mireille Bossy, Madalina Deaconu, Antoine Lejay, Sylvain Maire, Khaled Salhi, Denis Talay, Etienne Tanré.

7.2.1. Published works and preprints

- In collaboration with Jerome Lelong and Christophe Deluigi, Sylvain Maire built a new algorithm for the automatic integration and approximation of irregular functions [18]. This algorithm is tested numerically on the pricing of multidimensional exotic options.
- In collaboration with V. Reutenauer and C. Michel (CA-CIB), D. Talay and E. Tanré worked on a model in financial mathematics including bid-ask spread cost. They study the optimal strategy to hedge an interest rate swap that pays a fixed rate against a floating rate. They present a methodology using a stochastic gradient algorithm to optimize strategies. A paper is in revision [55].

7.2.2. Other works in progress

- K. Salhi works on partial hedging of options in an incomplete market, under constraints on the initial capital of the investor and assuming that the stock price is described by a Lévy process. In this case, perfect hedging is no more possible and we talk about partial hedging and minimization of risk. K. Salhi focuses on the Conditional Value-at-Risk minimization. He tries to give a numerical approximation to the solution in this context.
- In collaboration with J. Bion-Nadal (Ecole Polytechnique and CNRS), D. Talay pursued the study of a new calibration methodology based on dynamical risk measures and stochastic control PDEs.

8. Bilateral Contracts and Grants with Industry

8.1. Bilateral Contracts with Industry

- TOSCA Sophia is involved in a Cifre convention with Koris International. M. Bossy supervises M. Bonelli’s Ph.D. thesis.
- TOSCA Nancy had a bilateral contract coordinated by M. Deaconu with the SME Alphability on financial risk measures with applications in portfolio management.
- 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.

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).
- A. Lejay is member of the ANR H2MNO4 (Original Optimized Object Oriented Numerical Model for Heterogeneous Hydrogeology, ANR Cosinus, 2012–2015) coordinated by Joceyline Erhel (IRISA, Rennes).
- E. Tanré is member of the ANR SloFaDyBio (Slow Fast Dynamics in Biology, ANR-14-CE25-0019, 2015-2017) coordinated by M. Desroches (EPI NEUROMATHCOMP, Inria Sophia Antipolis).

9.1.2. Contract with ADEME

Participants: Mireille Bossy, Sélim Kraria.

Modéol Since April 2013, M. Bossy was the coordinator of the MODÉOL collaboration project funded by the French Environment and Energy Agency (ADEME), and involving the IPSL (CNRS) and the French company Maïa Eolis. The overall goal of the project concerns the modeling and prediction of wind potential in France, in particular the quantification of uncertainties and the analysis of multi-scale variability.

Concerning the Inria workpackage, in collaboration with Antoine Rousseau, from the team LEMON, we completed the SDM code with complex terrain description. We also improved the downscaling procedure that allows SDM to downscale its own simulation outputs.

9.2. European Initiatives

9.2.1. FP7 & H2020 Projects

- J. Inglis is a member of the European project MatheMACS (European Union Seventh Framework Programme no. 318723).

9.3. International Initiatives

9.3.1. Inria International Labs

Inria Chile

Associate Team involved in the International Lab:

9.3.1.1. ANESTOC-TOSCA

Title: Stochastic modelling of biology and renewable energies

International Partner (Institution - Laboratory - Researcher):

Pontificia Universidad Católica de Chile (Chile) - ANESTOC Center (ANESTOC) - Rebolledo Rolando

Start year: 2014

See also: http://www.anestoc.cl/es/?page_id=1112

This French-Chilean Associated Team deals with stochastic modeling and simulation issues for renewable energies (wind and waves) and neurosciences. It is a follow-up of a long collaboration in which each of the side takes benefit from the other side know-how and structures. This project aims at transfering and valuing to Chilean companies the results of researches on renewable energies, mainly wind prediction at the windfarm's scale and waves energy potential of a site using video.

Mireille Bossy is managing the WINDPOS project, in collaboration with Antoine Rousseau (LEMON team) and two engineers of Inria Chile, Cristian Paris and Jacques Morice. Based on the stochastic Lagrangian modeling of the wind at small scale (see SDM SOFTWARE), WINDPOS aims to develop a wind farm simulator software, able to provide fine statistical information for the managing of electricity production.
This year the WINDPOS project focused on the validation of the approach by comparison with measurements. We also tested the simulation of a 10 mills farm in complexe terrain with strong elevation.

Antoine Lejay is working with Rolando Rebolledo (PUC) on the stochastic modeling of the Oscillating Water Column to transform waves into energy.

9.4. International Research Visitors

9.4.1. Visits of International Scientists

- L. Beznea (Simion Stoilow Institute of Mathematics of the Romanian Academy, Bucarest) has been visiting TOSCA Nancy for 10 days in March.
- B. Cloez (INRA Montpellier) has been visiting TOSCA Nancy for 3 days in January.
- J. Claisse (Ecole Polytechnique) has been visiting TOSCA Nancy for 3 days in January.
- F. Campillo (LEMON team, Inria Sophia) has been visiting TOSCA Nancy for one week in August.
- M. Andrade Resptrepo (Univ. Paris 7) has been visiting TOSCA Nancy for 3 days in December.
- The TOSCA *seminar* organized by J. Inglis and A. Richard in Sophia Antipolis has received the following speakers: Cédric Bernardin (Laboratoire Dieudonné, Université Nice Sophia-Antipolis), Romuald Elie (Ceremade, Université Paris Dauphine), Roberta Evangelista (NEUROMATHCOMP-TOSCA, Inria Sophia-Antipolis), José R. León (Inria Grenoble, UCV de Venezuela), Soledad Torres (CIMFAV – Valparaiso, Chile), Arnulf Jentzen (ETH Zurich), Marielle Simon (PUC, Rio de Janeiro), Philip Protter (Columbia University), Jean-François Jabir (CIMFAV – Valparaiso, Chile), Sean Ledger (University of Oxford), Alexandre Brouste (Université du Maine, Le Mans).

9.4.1.1. Internships

CHIKHAOUI Maroua

Subject: Gestion de risque de portefeuille : Estimation de VaR et CVaR

Date: May 2015 - Sept. 2015

Institution: ESPRIT (Ecole Supérieure Privée d'Ingénierie et de Technologie, Tunisie) et Polytech'Nice-Sophia.

CORMIER Quentin

Subject: Réseaux de neurones à décharge avec phénomènes de plasticité

Date: Oct. 2015 - Feb. 2016

Institution: ENS Lyon.

EVANGELISTA Roberta

Subject: A stochastic model of gamma phase modulated orientation selectivity

Date: May 2015 - Sept. 2015

Institution: the Master in computational neuroscience, at the BCCN Berlin.

9.4.2. Visits to International Teams

9.4.2.1. Research stays abroad

- A. Richard has spent two weeks in Valparaíso and Santiago (Chile) in January, and two weeks in Santiago in June, working with R. Rebolledo and S. Torres.

10. Dissemination

10.1. Promoting Scientific Activities

10.1.1. Promotion of Mathematics in the industry

- M. Deaconu was invited to give a talk at the Workshop *Table ronde Assurance*, on october 2015, in Luxembourg.
- 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.
- 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.

10.1.2. Scientific events organisation

- M. Deaconu organized an interdisciplinary workshop: Avalanches and rupture phenomena, 3-4 February 2015 in Nancy. URL: http://iecl.univ-lorraine.fr/~Madalina.Deaconu/workshop2015
- E. Tanré animates a transverse working group . In 2015, Philip Protter (Columbia University) gave lectures on Brownian Motion and Poisson Processes (six courses with around 45 participants issued from 12 teams).
- E. Tanré has organized two mini-courses for the interdisciplinary axe of University of Nice "Modélisation Théorique et Computationnelle en Neurosciences et Sciences Cognitives". B. de Saporta (University of Montpellier) gave a course on Piecewise deterministic Markov Processes. M. Thieullen (University Paris 6) gave a course on a "Probabilistic study of membrane potential models, including ionic channels."
- D. Villemonais organized a mini-symposium at the *Congrès SMAI 2015*, at Les Karellis in June 2015.

10.1.2.1. Member of the organizing committees

- J. Inglis and E. Tanré were members of the organizing committee of the First International Conference on Mathematical NeuroScience (ICMNS) in Juan-les-Pins (June 2015), 170 participants.

10.1.3. Scientific events selection

10.1.3.1. Chair of conference program committees

- D. Talay organized and chaired the NASPDE 2015 conference in Sophia Antipolis (September 2015), 50 participants.

10.1.3.2. Member of the conference program committees

- A. Lejay is member of the conference program committees of *CANUM 2016* (Obernai, France) and *Journées de Probabilités 2015* (Toulouse, France).
- D. Talay served as a member of the scientific committee of the First International Conference on Mathematical NeuroScience (ICMNS) in Juan-les-Pins (June 2015), 2015 Conference in Stochastic Analysis and Mathematical Physics in Chile (September 2015), Conference in the honor of Vlad Bally (Le Mans, October 2015).

10.1.4. Journal

10.1.4.1. Member of the editorial boards

- N. Champagnat served as an Associate Editor of *Stochastic Models*.
- A. Lejay is one of the three editors of the *Séminaire de Probabilités*.
- M. Bossy served as an Associate Editor of *Annals of Applied Probability*.
- D. Talay served as an Associate Editor of: *Stochastic Processes and their Applications*, *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 served as the Co-editor in chief of *MathematicS in Action*.

10.1.4.2. Reviewer - Reviewing activities

- M. Bossy wrote reviews for manuscripts submitted to *Bernoulli Journal*, *Stochastic Processes and their Applications*.
- N. Champagnat wrote reviews for manuscripts submitted to *Journal of Mathematical Biology*, *Bernoulli Journal*, *Stochastic Processes and their Applications*, *Journal of Theoretical Biology*.
- M. Deaconu wrote reviews for *Mathematical Reviews of the American Mathematical Society (MathSciNet)* and for manuscripts submitted to *Mathematics and Computers in Simulation*, *ESAIM: Mathematical Modelling and Numerical Analysis*, *Journal of Computational and Applied Mathematics*, *Revue Roumaine de Mathématiques Pures et Appliquées* and *Journal of Nonlinear Analysis: Real World Applications*.
- C. Fritsch wrote reviews for manuscripts submitted to *Stochastic Models* and *Ecological Modelling*.
- J. Inglis wrote reviews for *Mathematical Reviews of the American Mathematical Society (MathSciNet)* and for manuscripts submitted to *Annales de l'Institut Henri Poincaré*.
- A. Lejay wrote reviews for manuscripts submitted to *Electronic Journal of Probability*, *Journal of Computational Mathematics*, *Journal of Mathematical Analysis and Applications*, *Journal of Scientific Computing*. *Journal of Statistical Computation and Simulation*, *Mathematics and Computers in Simulation*, *Probability and Mathematical Statistics SIAM Journal of Control and Optimization* and *SIAM Journal of Mathematical Analysis*.
- E. Tanré wrote reviews for manuscripts submitted to *Bernoulli Journal*, *The Journal of Mathematical Neuroscience*, *Applied Mathematical Finance*, *Annales de l'Institut Henri Poincaré*, *Probabilistic Engineering Mechanics*.
- D. Villemonais wrote reviews for*Mathematical Reviews of the American Mathematical Society (MathSciNet)* and for manuscripts submitted to *Science China Mathematics*, *Journal of Inequalities and Applications*, *Theoretical Population Biology* and *Electronic Communications in Probability*.

10.1.5. Invited talks

- M. Bossy has been invited to give talks at the *Workshop on "Subgrid-scale modeling for particle simulations in LES"* (Chatou) in March, at the *Workshop EDS Incertitudes of GDR MascotNum* (Paris) in May, at the *workshop "probabilistic numerical methods for non-linear PDE"* ICL (London) in June, and at the *NASPDE Workshop*, (Sophia Antipolis) in September.
- M. Bossy gave seminar talks at the MFEE departement EDF Chatou, and a Colloqium talk at LJAD (Nice) in November.
- N. Champagnat has been invited to give talks at the *Conference on Probability and Biological Evolution* at CIRM (Luminy), Marseille in June; at the *MMEE 2015* conference (Mathematical Models in Ecology and Evolution) in Paris in July; the *Workshop on Probabilistic models in Biology* in Playa del Carmen, Mexico, in October; and the *Colloque Franco-Maghrébin en Analyse Stochastique* in Nice in November.

- M. Deaconu has been invited to give talks to the *Eighth Congress of Romanian Mathematicians,* June 26-July 1, 2015, Iaşi, Romania; and the *Rencontre EDP/Probas*, March 6, 2015, Institut Henri Poincaré, Paris.
- C. Fritsch has been invited to give talks at the *Congrès SMAI 2015*, at Les Karellis in June and at the MMEE 2015 conference (*Mathematical Models in Ecology and Evolution*) in Paris in July.
- B. Henry has been invited to give talks at the *Congrès SMAI 2015*, at Les Karellis in June and at the *SPA Conference* (Sotchastic processes and applications) in Oxford in July. He also presented a poster at the MMEE 2015 conference (*Mathematical Models in Ecology and Evolution*) (Paris, July).
- J. Inglis gave a talk at the workshop *QFT methods in neuronal networks dynamics* at the University of Bielefeld, as part of the Mathemacs European project.
- A. Lejay has been invited to give talks at the *Conference in honor of Professor Vlad Bally* (Le Mans, October), the conference *Stochastic Analysis and Numerical Perspectives* (Sophia-Antipolis, September), the *AMS / EMS / SPM International Meeting* (Porto, June), the *Stochastic analysis, controlled dynamical systems an applications* (Iena, February).
- A. Lejay also gave seminar talks at Univ. Paris 6 in June, Univ. Marne-la-Vallée in May and CMAP (École Polytechnique) in February.
- P. Pigato gave seminar talks at the *Séminaire de probabilités et statistiques* of IECL, Univ. Lorraine, in November, and at the *Séminaire de probabilités et statistiques* of Laboratoire Dieudonné, Univ. Nice, in December.
- A. Richard gave an invited talk at the *French-Maghrebi conference on stochastic analysis* held in Nice in November, and seminar talks at the *IECL Probability Seminar* in March, at the *Seminar of the CIMFAV* (Valparaíso) in June.
- K. Salhi gave a talk at the 8th European Summer School in Financial Mathematics (Le mans, September 2015) . He also participated to the Advanced Risk and Portfolio Management bootcamp 2015 organized by SYMMYS (New York University, July 2015).
- D. Talay gave a seminar at Ecole Polytechnique in March and at Paris 6 university in May.
- D. Talay gave an invited talk at the 2015 Conference on Stochastic Analysis and Mathematicla Physics (Chile, September 2015) and at the Conference of the Honor of Vlad Bally (Le Mans, October 2015).
- E. Tanré gave invited talks at the ANR SloFaDyBio meeting in March, at an HBP-EITN workshop in April, and a seminar talk at the *IECL Probability Seminar* in October.
- D. Villemonais has been invited to give a lecture on quasi-stationary distributions at the LPMA (Paris) during the *Thematic meeting of the STAB ANR project* of November 2015.

10.1.6. Scientific expertise

- M. Bossy wrote reports about research projects submitted to the PACA Region council.
- M. Bossy was member of the hiring committee 26 PRF 4320 (Univ. Nice).
- N. Champagnat reported on a proposal submitted to ANR (Agence Nationale de la Recherche).
- N. Champagnat was member of the hiring committee 26 MCF 1219 (Univ. Paul Sabatier, Toulouse III).
- M. Deaconu was member of the hiring committee 26 MCF 0221 (Univ. Bourgogne) and of the hiring committee 26 MCF 80 (Univ. Bordeaux).
- D. Villemonais was member of the hiring committee 26 MCF 0706 (IUT de Dijon).
- D. Talay reported on applications to Research Grants Council (RGC) of Hong Kong.
- D. Talay participated in a Professor position recruitment committee at Paris 7 University.

10.1.7. Research administration

- M. Bossy is a elected member of the Inria Evaluation Board.
- M. Bossy has been a member of the Committee for junior permanent research positions of Inria Grenoble Rhône-Alpes.
- M. Bossy is a member of the *Collectif Andromede* of the PACA Region council.
- N. Champagnat is a member of the *Commission de Développement Technologique* and the *Commission Information Scientifique et Technique* of Inria Nancy - Grand Est, a subsitute member of the *Comité de Centre* 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 also local correspondent of the COERLE (*Comité Opérationel d'Évaluation des Risques Légaux et Éthiques*) for the Inria Research Center of Nancy - Grand Est. This year, together with Aline Wagner (Inria Nancy - Grand Est), he is in charge of the new version of the application form for research approval by the COERLE (ethical committe of Inria).
- M. Deaconu is a member of the *Bureau du Comité de Projet* of Inria Nancy - Grand Est, and of the *Comité de Projet* of Inria Nancy - Grand Est.
- A. Lejay is a member of the Administration Council of the SMAI.
- A. Lejay is a member of the COMIPERS of Inria Nancy Grand-Est.
- A. Lejay has been appointed as representative of Inria Nancy-Grand Est in the Agence Mathématiques et Entreprise (AMIES)

10.2. Teaching - Supervision - Juries

10.2.1. Teaching

Master: M. Bossy, *Continuous time stochastic models for quantitative Finance*, 45h, M2 IMAFA (Informatique et Mathématiques Appliquées à la Finance et à l'Assurance), École Polytechnique Universitaire, Univ. Nice - Sophia Antipolis, France.

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 Paris 6, France.

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

Master: N. Champagnat, *Introduction to Quantitative Finance*, 18h, M2, École des Mines de Nancy, France.

Master: N. Champagnat, *Processus de Markov et génétique des populations*, 22.5h, M2 MFA, Université de Lorraine, France.

Master: N. Champagnat, *Processus de Galton-Watson*, 22.5h, M2 "double diplôme" Mathématiques et Applications - Ecole Supérieure des Sciences et de Technologie de Hammam Sousse, Tunisie (lieu des cours) - Université de Lorraine, France.

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

Master: M. Deaconu, *Simulation de variables aléatoires*, 12h, M1, 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, *Introduction à la finance quantitative*, 3h, M1, École des Mines de Nancy, France.

Licence: C. Fritsch, *Analyse numérique*, 18h, L3, École des Mines de Nancy, France.

Licence: B. Henry, *Analyse numérique*, 18h, L3, École des Mines de Nancy, France.

Licence: B. Henry, *Probabilités*, 36h, L3, École des Mines de Nancy, France.

Master: J. Inglis, *Numerical Methods for Computational Finance*, 15h, M2, UNSA (Mathmods Erasmus Mundus), France.

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

Master: A. Lejay, *Probabilités Appliquées*, 22.5h, M2, Université de Lorraine (Nancy), France.

Master: A. Richard and E. Tanré, *Advanced Numerics for Computational Finance*, 40h (2*20h), M2, UNSA (Mathmods Erasmus Mundus), France.

Licence: K. Salhi, *Mathématiques Appliquées et Probabilités*, 24h, L3, Télécom Nancy, France

Master: K. Salhi, *Probabilités et Statistiques*, 42h, M1, ENSEM Nancy, France.

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

Master: E. Tanré, *Numerical Probability in Finance*, 44h, M2, Ecole PolytechNice (IMAFA), France.

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

10.2.2. Supervision

- HdR: Nicolas Champagnat, *Approches stochastiques et déterministes en biologie: dynamique adaptative, modélisation pour l'écologie, génétique des populations et dynamique moléculaire; caractère bien posé d'équations différentielles ordinaires et stochastiques*, Univ. Lorraine, 18 February 2015.
- PhD : Lionel Lenôtre, *Étude et simulation de processus de diffusion biaisés*, Université Rennes 1, November 27, 2015, Jocelyne Erhel (Irisa), Antoine Lejay, Géraldine Pichot (Irisa).
- PhD in progress: Maxime Bonelli, *Behavioral finance approach to risk assessment in quantitative portfolio management*, September 2013, M. Bossy.
- PhD in progress: Antone Brault, *Équations rugueuses linéaires*, October 2015, Laure Coutin (Université Toulouse III) and A. Lejay.
- PhD in progress: Baldwin Dumortier, *Contrôle acoustique des éoliennes*, October 2014, M. Deaconu and E. Vincent (EPI MULTISPEECH).
- PhD in progress: Benoît Henry, *Modeling Evolutionary Relationships Between Three-Dimensional Protein Structures*, October 2013, N. Champagnat, D. Ritchie (EPI ORPAILLEUR).
- PhD in progress: Radu Maftei, *A stochastic approach to colloidal particle agglomeration in turbulent flows*, November 2014, M. Bossy.
- PhD in progress: Khaled Salhi, *Estimation of Risk in Finance*, October 2013, M. Deaconu and A. Lejay.
- PhD in progress: Milica Tomasevic, *Stochastic approaches to Keller–Segel equations*, October 2015, D. Talay.

10.2.3. Juries

- M. Bossy served as a referee for the Ph.D. theses of Bénédicte Jourdier, *Ressource éolienne en France métropolitaine : méthodes d'évaluation du potentiel, variabilité et tendances*, École Polytechnique, September 2015, and of Lucie Rottner, *Reconstruction de l'atmosphère turbulente à partir d'un lidar Doppler 3D et étude du couplage avec Meso-NH*, Université Toulouse III Paul Sabatier, December 2015.

- M. Bossy served as an examiner for the Ph.D. thesis of M. Michaël Benguigui, *Valorisation d'option américaine et Value At Risk de portefeuille sur cluster de GPUs/CPUs hétérogène*. Université de Nice, August 2015.
- N. Champagnat served as a referee for the Ph.D. theses of Cristobal Quininao, *Mathematical modeling in Neuroscience: collective behavior of neuronal networks and the role of local homeoproteins diffusion in morphogenesis*, UPMC, June 2, 2015, and of Marie-Noémie Thai, *Processus de Fleming-Viot, distributions quasi-stationnaires et marches aléatoires en interaction de type champ moyen*, Univ. Paris-Est, November 27, 2015.
- A. Lejay served as an examiner for the Ph.D. thesis of Thi Quynh Giang Nguyen, *Méthodes de Monte Carlo pour les diffusions discontinues : application à la tomographie par impédance électrique*, Université de Toulon, October 2015; of Willian Minvielle, *Some problems related to statistical error in stochastic homogenization*, Université Paris-Est, October, 2015; of Lionel Lenôtre, *Étude et simulation de processus de diffusion biaisés*, Université Rennes 1, November, 2015 and of Johann Nicod, *Approximation numérique par chaos de Wiener de quelques EDPS*, Université Paris-Est, December 2015.
- D. Talay served as an examiner for the HdR of Nicolas Champagnat (see above) and the Ph.D. theses of Lorick Huang, *EDS dirigées par des processus stables. Méthode parametrix pour des estimées de densités et application aux algorithmes stochastiques*, Université Paris Diderot Sorbonne Paris Cité, July 2015, and of Athena Picarelli, *Sur des problèmes de contrôle stochastique avec contraintes sur l'état*, Ecole Polytechnique, April 2015. He also served as a referee for the Ph.D. thesis of Clément Rey, *Etude et Modélisation d'équations différentielles stochastiques*, Paris-Est university, December 2015.

10.3. Popularization

- M. Deaconu gave an interview for a paper in Eureka Lorraine. URL : http://eureka.lorraine.eu/jahia/Jahia/pid/1968?actu=23647

11. Bibliography

Major publications by the team in recent years

[1] L. BEZNEA, M. DEACONU, O. LUPASCU. *Branching processes for the fragmentation equation*, in "Stochastic Processes and their Applications", 2015, vol. 125, pp. 1861-1885 [*DOI :* 10.1016/J.SPA.2014.11.016], https://hal.inria.fr/hal-00948876

[2] M. BOSSY, J.-F. JABIR. *Lagrangian stochastic models with specular boundary condition*, in "Journal of Functional Analysis", March 2015, vol. 268, n^o 6, pp. 1309–1381, https://hal.inria.fr/hal-00875040

[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

[4] N. CHAMPAGNAT, S. MÉLÉARD. *Polymorphic evolution sequence and evolutionary branching*, in "Probab. Theory Related Fields", 2011, vol. 151, n^o 1-2, pp. 45–94, http://dx.doi.org/10.1007/s00440-010-0292-9

[5] N. CHAMPAGNAT, D. VILLEMONAIS. *Exponential convergence to quasi-stationary distribution and Q-process*, in "Probability Theory and Related Fields", 2016, 46 pages [*DOI :* 10.1007/S00440-014-0611-7], https://hal.archives-ouvertes.fr/hal-00973509

[6] L. COUTIN, A. LEJAY. *Perturbed linear rough differential equations*, in "Annales mathématiques Blaise Pascal", April 2014, vol. 21, n^o 1, pp. 103-150, https://hal.inria.fr/hal-00722900

[7] M. DEACONU, S. HERRMANN. *Hitting time for Bessel processes—walk on moving spheres algorithm (WoMS)*, in "Ann. Appl. Probab.", 2013, vol. 23, n^o 6, pp. 2259–2289, http://dx.doi.org/10.1214/12-AAP900

[8] F. DELARUE, J. INGLIS, S. RUBENTHALER, E. TANRÉ. *Global solvability of a networked integrate-and-fire model of McKean-Vlasov type*, in "Annals of Applied Probability", January 2015, vol. 25, n^o 4, pp. 2096–2133, Version 4: shortened version, https://hal.inria.fr/hal-00747565

[9] J. INGLIS, D. TALAY. *Mean-field limit of a stochastic particle system smoothly interacting through threshold hitting-times and applications to neural networks with dendritic component*, in "SIAM Journal on Mathematical Analysis", 2015, vol. 47, n^o 15, pp. 3884–3916 [*DOI :* 10.1137/140989042], https://hal.inria.fr/hal-01069398

[10] A. LEJAY. *The snapping out Brownian motion*, in "Annals of Applied Probability", September 2015, https://hal.inria.fr/hal-00781447

Publications of the year

Doctoral Dissertations and Habilitation Theses

[11] N. CHAMPAGNAT. *Stochastic and deterministic approaches in Biology: adaptive dynamics, ecological modeling, population genetics and molecular dynamics; Well-posedness for ordinary and stochastic differential equations*, Université de Lorraine, February 2015, Habilitation à diriger des recherches, https://hal.inria.fr/tel-01188203

Articles in International Peer-Reviewed Journals

[12] L. BEZNEA, M. DEACONU, O. LUPASCU. *Branching processes for the fragmentation equation*, in "Stochastic Processes and their Applications", 2015, vol. 125, pp. 1861-1885 [*DOI :* 10.1016/J.SPA.2014.11.016], https://hal.inria.fr/hal-00948876

[13] L. BEZNEA, M. DEACONU, O. LUPASCU. *Stochastic equation of fragmentation and branching processes related to avalanches*, in "Journal of Statistical Physics", November 2015, Accepté pour publication, https://hal.inria.fr/hal-01216137

[14] M. BOSSY, N. CHAMPAGNAT, H. LEMAN, S. MAIRE, L. VIOLEAU, M. YVINEC. *Monte Carlo methods for linear and non-linear Poisson-Boltzmann equation*, in "ESAIM: Proceedings", January 2015, 27 p. , https://hal.inria.fr/hal-01088930

[15] M. BOSSY, O. FAUGERAS, D. TALAY. *Clarification and Complement to " Mean-Field Description and Propagation of Chaos in Networks of Hodgkin–Huxley and FitzHugh–Nagumo Neurons "*, in "Journal of Mathematical Neuroscience", 2015, vol. 5, n^o 1, 19 p. [*DOI :* 10.1186/S13408-015-0031-8], https://hal.inria.fr/hal-01098582

[16] M. BOSSY, J.-F. JABIR. *Lagrangian stochastic models with specular boundary condition*, in "Journal of Functional Analysis", March 2015, vol. 268, n^o 6, pp. 1309–1381, https://hal.inria.fr/hal-00875040

[17] N. CHAMPAGNAT, D. VILLEMONAIS. *Exponential convergence to quasi-stationary distribution and Q-process*, in "Probability Theory and Related Fields", 2016, 46 pages [*DOI :* 10.1007/S00440-014-0611-7], https://hal.archives-ouvertes.fr/hal-00973509

[18] C. DE LUIGI, J. LELONG, S. MAIRE. *Adaptive numerical integration and control variates for pricing Basket Options*, in "Applied Numerical Mathematics", 2016, vol. 100, 17 p. , https://hal.archives-ouvertes.fr/hal-00746872

[19] M. DEACONU, S. HERRMANN, S. MAIRE. *The walk on moving spheres: a new tool for simulating Brownian motion's exit time from a domain*, in "Mathematics and Computers in Simulation", 2015, https://hal.archives-ouvertes.fr/hal-00931816

[20] F. DELARUE, J. INGLIS, S. RUBENTHALER, E. TANRÉ. *Global solvability of a networked integrate-and-fire model of McKean-Vlasov type*, in "Annals of Applied Probability", January 2015, vol. 25, n^{o} 4, pp. 2096–2133, Version 4: shortened version, https://hal.inria.fr/hal-00747565

[21] F. DELARUE, J. INGLIS, S. RUBENTHALER, E. TANRÉ. *Particle systems with a singular mean-field self-excitation. Application to neuronal networks*, in "Stochastic Processes and Applications", 2015, vol. 125, pp. 2451–2492 [*DOI :* 10.1016/J.SPA.2015.01.007], https://hal.inria.fr/hal-01001716

[22] I. T. DIMOV, S. MAIRE, J.-M. SELLIER. *A New Walk on Equations Monte Carlo Method for Linear Algebraic Problems*, in "Applied Mathematical Modelling", August 2015, vol. 39, n^{o} 15 [*DOI :* 10.1016/J.APM.2014.12.018], https://hal.inria.fr/hal-00979044

[23] S. HERRMANN, E. TANRÉ. *The first-passage time of the Brownian motion to a curved boundary: an algorithmic approach*, in "SIAM Journal on Scientific Computing", January 2016, vol. 38, n^{o} 1, 20 p. [*DOI :* 10.1137/151006172], https://hal.inria.fr/hal-01110387

[24] A. LEJAY. *The snapping out Brownian motion*, in "Annals of Applied Probability", September 2015, https://hal.inria.fr/hal-00781447

[25] S. MAIRE, G. NGUYEN. *Stochastic finite differences for elliptic diffusion equations in stratified domains*, in "Mathematics and Computers in Simulation", March 2016, vol. 121 [*DOI :* 10.1016/J.MATCOM.2015.09.008], https://hal.inria.fr/hal-00809203

[26] S. MAIRE, M. SIMON. *A partially reflecting random walk on spheres algorithm for electrical impedance tomography*, in "Journal of Computational Physics", December 2015, vol. 303 [*DOI :* 10.1016/J.JCP.2015.10.005], https://hal.inria.fr/hal-01253538

[27] A. RICHARD. *A fractional Brownian field indexed by L^2 and a varying Hurst parameter*, in "Stochastic Processes and their Applications", April 2015, vol. 125, https://hal.inria.fr/hal-00922028

[28] X. THANH VU †, S. MAIRE, C. CHAUX, N. THIRION-MOREAU. *A new stochastic optimization algorithm to decompose large nonnegative tensors*, in "IEEE Signal Processing Letters", 2015, 12 p. , https://hal.archives-ouvertes.fr/hal-01146443

[29] D. VILLEMONAIS. *Minimal quasi-stationary distribution approximation for a birth and death process*, in "Electronic Journal of Probability", March 2015, vol. 20, n^{o} 30, pp. 1-18, The new version provides an original Lyapunov-type criterion for the ξ_1-positive recurrence of a birth and death process. An original result on the

domain of attraction of the minimal quasi-stationary distribution of a birth and death processes is also included. (26 pages) [*DOI :* 10.1214/EJP.v20-3482], https://hal.archives-ouvertes.fr/hal-00983773

International Conferences with Proceedings

[30] B. DUMORTIER, E. VINCENT, M. DEACONU. *Acoustic Control of Wind Farms*, in "EWEA 2015 - European Wind Energy Association", Paris, France, November 2015, https://hal.inria.fr/hal-01233730

Scientific Books (or Scientific Book chapters)

[31] 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

Research Reports

[32] N. CHAMPAGNAT, M. DEACONU, A. LEJAY, A. BEDOUI. *Analyse de dépendance d'actifs financiers par la méthode des copules*, Inria, February 2015, 61 p. , https://hal.inria.fr/hal-01114790

[33] A. LEJAY. *Estimation of the mean residence time in cells surrounded by semi-permeable membranes by a Monte Carlo method*, Inria Nancy - Grand Est (Villers-lès-Nancy, France) ; Inria, April 2015, n° RR-8709, https://hal.inria.fr/hal-01140960

Other Publications

[34] M. BAAR, A. BOVIER, N. CHAMPAGNAT. *From stochastic, individual-based models to the canonical equation of adaptive dynamics - In one step*, 2015, working paper or preprint, https://hal.inria.fr/hal-01188189

[35] M. BOSSY, J.-F. JABIR. *Particle approximation for Lagrangian Stochastic Models with specular boundary condition*, April 2015, working paper or preprint, https://hal.inria.fr/hal-01147441

[36] M. BOSSY, H. O. QUINTEROS. *Strong convergence of the symmetrized Milstein scheme for some CEV-like SDEs*, August 2015, working paper or preprint, https://hal.archives-ouvertes.fr/hal-01185353

[37] F. CAMPILLO, N. CHAMPAGNAT, C. FRITSCH. *Links between deterministic and stochastic approaches for invasion in growth-fragmentation-death models*, September 2015, working paper or preprint, https://hal.archives-ouvertes.fr/hal-01205467

[38] F. CAMPILLO, N. CHAMPAGNAT, C. FRITSCH. *On the variations of the principal eigenvalue and the probability of survival with respect to a parameter in growth-fragmentation-death models*, January 2016, working paper or preprint, https://hal.inria.fr/hal-01254053

[39] N. CHAMPAGNAT. *Processus de Galton-Watson et applications en dynamique des populations*, October 2015, 46 p. , Lecture, https://hal.inria.fr/cel-01216832

[40] N. CHAMPAGNAT, B. HENRY. *Moments of the frequency spectrum of a splitting tree with neutral Poissonian mutations*, September 2015, working paper or preprint, https://hal.archives-ouvertes.fr/hal-01202732

[41] N. CHAMPAGNAT, P.-E. JABIN. *Strong solutions to stochastic differential equations with rough coefficients*, September 2015, working paper or preprint, https://hal.inria.fr/hal-00799242

[42] N. CHAMPAGNAT, D. VILLEMONAIS. *Exponential convergence to quasi-stationary distribution for absorbed one-dimensional diffusions with killing*, October 2015, working paper or preprint, https://hal.inria.fr/hal-01217843

[43] N. CHAMPAGNAT, D. VILLEMONAIS. *Exponential convergence to quasi-stationary distribution for one-dimensional diffusions*, June 2015, working paper or preprint, https://hal.inria.fr/hal-01166960

[44] N. CHAMPAGNAT, D. VILLEMONAIS. *Quasi-stationary distribution for multi-dimensional birth and death processes conditioned to survival of all coordinates*, August 2015, working paper or preprint, https://hal.inria.fr/hal-01188172

[45] M. CHIKHAOUI. *Gestion de risque de portefeuille : estimation de la VaR et CVaR*, Ecole Supérieure Privée d'Ingénierie et de Technologie, September 2015, https://hal.inria.fr/hal-01246153

[46] J. CLAISSE, D. TALAY, X. TAN. *A pseudo-Markov property for controlled diffusion processes*, January 2015, working paper or preprint, https://hal.inria.fr/hal-01108657

[47] L. COUTIN, A. LEJAY. *Sensitivity of rough differential equations*, March 2015, working paper or preprint, https://hal.inria.fr/hal-00875670

[48] P. DEL MORAL, D. VILLEMONAIS. *Exponential mixing properties for time inhomogeneous diffusion processes with killing*, January 2016, 23 pages. The introduction has been developped and the results are now compared with existing ones. Several examples have been added. Several misprints and weakly formulated arguments have been rewritten, https://hal.archives-ouvertes.fr/hal-01083297

[49] B. HENRY. *CLTs for general branching processes related to splitting trees*, September 2015, working paper or preprint, https://hal.archives-ouvertes.fr/hal-01202095

[50] J. INGLIS, J. MACLAURIN. *A general framework for stochastic traveling waves and patterns, with application to neural field equations*, June 2015, 43 pages, 3 figures, https://hal.archives-ouvertes.fr/hal-01169697

[51] J. INGLIS, D. TALAY. *Mean-field limit of a stochastic particle system smoothly interacting through threshold hitting-times and applications to neural networks with dendritic component*, September 2015, working paper or preprint, https://hal.inria.fr/hal-01069398

[52] A. KOHATSU-HIGA, A. LEJAY, K. YASUDA. *Weak rate of convergence of the Euler-Maruyama scheme for stochastic differential equations with non-regular drift*, May 2015, working paper or preprint, https://hal.inria.fr/hal-00840211

[53] A. LEJAY. *A Monte Carlo estimation of the mean residence time in cells surrounded by thin layers*, December 2015, working paper or preprint, https://hal.inria.fr/hal-01216471

[54] A. LEJAY, L. LENÔTRE, G. PICHOT. *One-dimensional skew diffusions: explicit expressions of densities and resolvent kernels*, December 2015, working paper or preprint, https://hal.inria.fr/hal-01194187

[55] C. MICHEL, V. REUTENAUER, D. TALAY, E. TANRÉ. *Liquidity costs: a new numerical methodology and an empirical study*, December 2015, working paper or preprint, https://hal.inria.fr/hal-01098096

[56] A. RICHARD. *Increment stationarity of L^2-indexed stochastic processes: spectral representation and characterization*, December 2015, working paper or preprint, https://hal.inria.fr/hal-01236156

[57] K. SALHI, M. DEACONU, A. LEJAY, N. CHAMPAGNAT, N. NAVET. *Regime switching model for financial data: empirical risk analysis*, February 2015, working paper or preprint, https://hal.inria.fr/hal-01095299

References in notes

[58] J. BALADRON, D. FASOLI, O. FAUGERAS, J. TOUBOUL. *Mean Field description of and propagation of chaos in networks of Hodgkin-Huxley and Fitzhugh-Nagumo neurons*, in "Journal of Mathematical Neuroscience", 2012, vol. 2, n° 10

[59] N. CHAMPAGNAT, S. MÉLÉARD. *Polymorphic evolution sequence and evolutionary branching*, in "Probab. Theory Related Fields", 2011, vol. 151, n° 1-2, pp. 45–94, http://dx.doi.org/10.1007/s00440-010-0292-9

[60] P. DEL MORAL, A. GUIONNET. *On the stability of interacting processes with applications to filtering and genetic algorithms*, in "Ann. Inst. H. Poincaré Probab. Statist.", 2001, vol. 37, n° 2, pp. 155–194, http://dx.doi.org/10.1016/S0246-0203(00)01064-5

[61] P. DEL MORAL, L. MICLO. *On the stability of nonlinear Feynman-Kac semigroups*, in "Ann. Fac. Sci. Toulouse Math. (6)", 2002, vol. 11, n° 2, pp. 135–175, http://www.numdam.org/item?id=AFST_2002_6_11_2_135_0