# Proyectos MATH AmSud - convocatoria 2018

## MADASEIS – Mathematical tools for the study of damage dynamics and microseismicity

Abstract

In this project we are interested in some mathematical aspects of solid mechanics and

microseismisity with applications in underground mining. Worldwide the mining activity is

facing lower grades, deeper ore bodies and stronger stresses within increasing massive

operations. These challenges have several technical difficulties and uncertainties and

associated systemic risks, which can affect the business survival and the long-term

sustainability of the operation.

For underground mine, the current technique for ore extraction is the called *block caving*,

which generates and induces seismic activity within the mine. In this setting, to reduce the

magnitudes and control the risk of big events, the rock massif is preconditioned using

extensively hydraulic fracturing technique since more than a decade.

The main goal of this project is to combine PDE, shape optimization, inverse problems

and numerical aspects of solid mechanics, for the understanding of fracturing of rock mass

and seismic waves propagation in heterogeneous media, with applications in underground

mine with operational geomechanical constraints coming from the seismic activity

induced by the production, parameters of the massif rock, hydraulic fractured rock,

geometry and boundary conditions of the cavities, tunnels and levels.

We will develop these models and tools integrating risks in the operation of the mine as

well as the development. For all these purposes, in our team will conduct frontier research

using a modern interdisciplinary approach combining mathematical modeling, solid

mechanical, mining, geomechanical and computer science expertise, and a long history in

applied projects in mining, including a strong international network. Furthermore, we

combine a team with senior and junior researchers and PhD students, contributing to the

formation of young researchers coming from several universities from Latin-America and

France.

Institutions and scientific coordinators:

Jaime H. Ortega - Universidad de Chile – CHILI

Juan Carlos López – Universidad Yachay Tech – ECUADOR

Rodrigo Lecaros – Universidad Federico Santa María – CHILI

Gino Montecinos – Universidad de Aysén – CHILI

Eric Bonnetier – Université de Grenoble - FRANCE

NMARKOVSOC – Stochastic analysis of non-Markovian phenomena

Abstract

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| The scientific project consists in the study of some fundamental questions associated with non-Markovian stochastic systems. Typically, the Markov property allows the use of classical PDE techniques to investigate several properties of stochastic differential equations in different contexts. More importantly, it allows us to associate stochastic systems with deterministic ones with many fruitful properties that opened the way to the derivation of several important results over the last sixty years. In the absence of the Markov property, the possible link with deterministic systems is much less obvious and a set of new tools and ideas must be developed. Recently, motivated by concrete problems arising in Physics, Finance, etc, important advances have been carry out focusing on the development of new integration and differentiation theories for systems exhibiting non-trivial memory, subject to uncertainty on parameters and possibly driven by highly irregular noises. This project aims to advance in some open questions in this area of research. The goal is to develop new techniques and solve concrete problems in three different contexts of a given non-Markovian system, namely: (1.1) Analysis of functional Itô-type formulas under a family of non-dominated finite quadratic variation probability measures. (1.2) Nonlinear functional Itô calculus. (2) Resolution of stochastic optimal control problems for controlled stochastic differential equations driven by a fractional Brownian motion with parameter H in (0,1). (3) Stochastic dynamics for path-dependent systems driven by Lévy noises. |

Institutions and scientific coordinators:

Alberto Ohashi – Universidade Federal da Paraíba – BRAZIL

Marcelo Fragoso – Laboratório Nacional de Computação Científica – BRAZIL

Paulo Ruffino - UNICAMP – BRAZIL

Michael Hoegele – Universidad de los Andes – COLOMBIA

Francesco Russo – ENSTA Paris Tech - FRANCE

## RareDep – Rare events analysis in multi-component systems with dependent components

Abstract

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| The RareDep project focus on developing new techniques addressing two central elements  for the improvement of the available tools for risk analysis of complex systems. One is the case of rare events, occurring both in performance and in dependability evaluation of systems modeled as made of many components. Rare events preclude the use of Monte Carlo techniques when the event of interest has a small probability of occurring, and specific methods are necessary, with many open problems in the area. Independence is the usual assumption when building models (more precisely, in almost all works in the field make this assumption), but we know that the assumption is almost never satisfied. We often are constrained by the necessity of assuming independent components in order to be able to use the available methods. In RareDep, we intend to address both problems simultaneously. This needs to develop new variance reduction techniques, for instance in the Importance Sampling family, or in the Splitting one, to be able to exploit data concerning dependencies between the components of the models.  This will be built on top of our cumulated experience in the Monte Carlo area (and related fields, such as Quasi-Monte Carlo, numerical integration, etc.), and a starting effort to begin the exploration of what happens when we relax the omnipresent independence hypothesis. We will also explore what happens if we consider new ideas (several coming from the participants of the proposal) for defining new metrics in some specific areas. In these cases, everything is to be done: procedures to deal with rare events, modeling techniques to deal with dependencies between the system’s components, and then, both issues at the same time. Our main application area will concern different types of modern networks (in communications, or in energy distribution, for instance).  Institutions and scientific coordinators:  Héctor Cancela – Universidad de la República – URUGUAY  Javiera Barrera – Universidad Adolfo Ibáñez – CHILE  Pablo Martín Rodríguez – Universidade de São Paulo – BRAZIL  Leslie Murray – Universidad Nacional de Rosario – ARGENTINA  Gerardo Rubino – INRIA Rennes-Bretagne Atlantique - FRANCE |
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## RGSD – Rigidity and Geometric Structures in Dynamics

Abstract

We present three very active research topics, each asking the same question. Describe the properties of a group by knowing its actions on spaces, which can be for example symmetric spaces, or low-dimensional manifolds. And recover dynamical obstructions for its actions knowing its algebraic and geometric properties. In particular, the questions of stability and rigidity are central. The first topic is the study of finitely generated groups of circle diffeomorphisms. The second one is the study of Anosov representations of hyperbolic groups. The third one is the study of cohomological dynamics of cocycles over hyperbolic systems, and its applications in group theory. The common philosophy is that when knowing the action of a group, one uses *dynamical* tools (distortion controls, dynamical formalism, or rigid inequalities) to construct *invariant* *geometric structures* and deduce the *rigidity* of the action.

Institutions and scientific coordinators:

Alejandro Kocsard – Universidade Federal Fluminense – BRAZIL

Sébastien Alvarez – Universidad de la República – URUGUAY

Andrés Sambarino – Sorbonne Université – FRANCE

## RSPSM – Random Structures and Processes in Statistical Mechanics

Abstract

We study different Random Structures and Processes in Statistical Mechanics. We are interested in

global properties such as recurrence/transience, invariant measures, and scaling limits. The main

problems we plan to study are: Late points for the Brownian motion on the 2-dimension torus;

Absorbing-state phase transitions; A stochastic model of deposition; Mean-field model of a directed

polymer in random environment; Intermediate disorder limit of random polymer models; A

stochastic model of erosion; Independent sets in large sparse random graphs; Wiener sausage

percolation; Explicit formulas and expansions for random walk in random environment; Branchingselection particle systems, traveling waves and q.s.d.; Interacting particle systems with unbounded interactions; Microscopic Turing instability.

Institutions and scientific coordinators:

Leonardo T. Rolla – MECCYT – ARGENTINA

Milton Jara – CAPES-IMPA – BRAZIL

Alejandro Ramírez – PUC – CONICYT – CHILE

Joaquín Fontbona – CMM – CHILI

Francis Comets – MEAE – CNRS – FRANCE

## SARC – Stochastic and Statistics analysis for Stochastic Differential equations driven by fractional Brownian motion with non regular coefficients

Abstract

In this project, we propose the study of Stochastic and Statistics analysis for stochastic differential equations driven by fractional Brownian motion with non-regular coefficients.

Specifically, we propose to study two main topics.

This first one is to study existence and uniqueness of solutions of SDE and the law of the solution stochastic differential equations driven by fractional Brownian motion with non-regular coefficients- In particular, we are interesting in the study of the properties of the density when the stochastic differential equations has a discontinuous coefficients or are of the power type. The second part of the proposal is deal with the Bayesian, parametric and non-parametric estimation of the parameters some statistical models related to stochastic differential de driven by fractional Brownian motion with non-regular coefficients.

This specific scientific goals of this project are as follows:

1. To study existence and uniqueness of SDE. With non-regular coefficients.
2. To propose an estimation procedure in the oscillating fractional Brownian motion.
3. To develop non-parametric estimation in some models with discontinuous noise.
4. To propose a Bayesian approach for the oscillating fractional Brownian motion and models with discontinuous coefficients.
5. To study the density of SDE with discontinuous coefficients.

Institutions and scientific coordinators:

Christian Olivera – Universidade Estadual de Campinas - BRAZIL

Soledad Torres – Universidad de Valparaíso – CHILE

Etienne Tanré – Université Sophia-Antipolis – FRANCE

Alexandre Richard – Centrale Supélec - FRANCE