# Proyectos MATH AmSud - convocatoria 2019

## ACIPDE - Analysis, Control and Inverse problems for Partial Differential Equations

Abstract

The objective of this project is two-folded. On one hand, we will study controllability properties to infinite dimensional systems modeled by partial differential equations. We will extend the theory in the case parabolic systems or hyperbolic systems with a particular attention to fluid systems. We also want to investigate the controllability of systems mixing hyperbolic and parabolic equations such as fluid-elastic interaction systems**.** We want in particular to develop new tools to handle coupled systems, where the coupling can appear as in a transmission problem. On the other hand, we will consider inverse problems for stationary, parabolic systems or hyperbolic systems with again a particular attention to fluid systems. We also want to tackle coupled/transmission systems such as fluid-structure interaction systems or cardiac models.

Institutions and scientific coordinators:

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ARGO - Algebraic Real Geometry and Optimization

Abstract

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| Real Algebraic Geometry deals with the study of the sets of real solutions of polynomial equalities (real algebraic varieties) or inequalities (semi algebraic sets). In optimization, one looks for local or global extrema of a real function on a set; problems in which both the function and the set are semi-algebraic play a fundamental role. Hence, Real Algebraic Geometry and Optimization are closely tied, and the advancement in each of the field requires progress in the other. In addition, the use of semi-algebraic techniques in Optimization, and more generally in Applied Mathematics, has been amplified during the last few years, because the most common operations arising in optimization, although destroying smoothness, respect semi-algebraicity. The current project deals with several key problems in Real Algebraic geometry, Polynomial and semi-algebraic Optimization, and with structural results in constrained optimization and nonsmooth dynamics. The project gather teams with complementary specialties, including real algebraic geometry, tropical geometry, symbolic computation, computational optimization, variational analysis, and dynamical systems (gradient flows), allowing to develop new interactions at the interface of pure and applied mathematics. |

Institutions and scientific coordinators:

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Stéphane Gaubert, Centre de Mathématiques Appliquées of École Polytechnique – CMAP, FRANCIA

## CCFEM - Concordance and Covariance Functions for Environmental Modelling

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| Abstract:  The concordance and spatial analyses are two sub-fields of statistics that have received considerable attention the last two decades. With the rapid development of computer sciences and the acquisition of large datasets, these two topics deserve more attention. Specially, when comparing two instruments, quantifying the spatial concordance, or specifying the covariance function for prediction purposes. In this project, these have been divided into three main topics called **T1**, **T2**, and **T3,** which constitutes the core of this proposal, arranged in such a way that allow us to approach the problems simultaneously. This project combines the experience and skills of statisticians, mathematicians, and Ph.D. students who will be devoted to creating new scientific knowledge and applications with relevant data and useful for society. |
| Institutions and scientific coordinators:  Ronny Vallejos, Advanced Center for Electrical and Electronic Engineering (AC3E)  Universidad Técnica Federico Santa María (UTFSM), CHILE  Mário De Castro, Instituto de Ciências Matemáticas e de Computação  Universidade de São Paulo (USP), BRASIL  Francois Bachoc, Institut de Mathématiques de Toulouse, Université Paul Sabatier, FRANCIA |

## EEQUADD-II - Nonlinear and Fractional Evolution EQUAtions: Dispersion, Dynamics, well-posedness and Functional Analytic tools

Abstract

This proposal describes our research program in the areas of nonlinear dispersive partial differential equations, intended for a period of 2 years. It predicts the collaboration between Brazilian, Chilean and French researchers and an extensive development of human resources. We present here a broad introduction to our research program as well as a list of several detailed research projects (some of which are already ongoing). These projects consider current topics of investigation such as: the qualitative study of the Cauchy problem for some dispersive equations and their study of properties of solutions to these problems.

Institutions and scientific coordinators:

Felipe Linares, IMPA, BRASIL

Michal Kowalczyk, DIM and CMM (UMI 2807), CHILE

Jean-Claude Saut, Université Paris Sud, FRANCIA

## FANTASTIC - Statistical inFerence and sensitivity ANalysis for models described by sTochASTIC differential equations

Abstract

The general aim of our research project is to tackle probabilistic and statistical issues driven by applications. It is divided in four axes. The first one deals with sensitivity analysis for parametrized stochastic differential equations (SDE), with an application to models arising in neurosciences. The aim is to rank uncertain parameters with respect to their influence on the variability of a quantity of interest, related to the solution of the SDE. The second one is concerned with the emergence of collective behaviors in particle systems with mean field interaction. The aim for this second axis is to enlarge the class of stochastic models with collective organization features for which a mathematical analysis is possible. The two last axes are more focused to statistical issues, namely non-parametric regression estimation with Poisson and Wiener covariates and the estimation of autoregressive random processes with random sampling times. Regression estimation with Poisson covariates arises e.g., in speech recording analysis. That axis will make use of concentration inequalities for suprema of integral functionals of Poisson processes, as far hypercontractivity properties. Concerning the last axis, it seems a natural issue to be studied, as deterministic sampling is not always a reasonable assumption. Specific random times have been treated in the literature. The aim on this axis is to handle more general classes of random designs.

Institutions and scientific coordinators:

Jose Leon, Universidad de la Repúbilica IMERL, Facultad de Ingeniería, URUGUAY

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Clémentine Prieur, Université Grenoble Alpes/ Centre Inria Grenoble Rhône-Alpes, FRANCIA

## NT-ACRT - Number Theory: interconnections with Algebra, Combinatorics and Representation Theory

Abstract

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| Number Theory is an emerging field of study in South America, and we will explore several of its interconnections with Algebra, Combinatorics and Representation Theory. We aim to stimulate interactions among students, young researchers and professors in the France-South America community. We will organize two workshops, where experts in the field from France and Latin America will gather to explore topics of current mathematical research. We will also promote the participation of women in mathematics and foster an atmosphere of academic excellence between participants of diverse backgrounds.  One conference will explore the interconnections between Number Theory and Representation Theory, to be held in Valparaíso, Chile, where the generalized reciprocity laws made possible by the Langlands Program will serve as a unifying theme among participants.  Another conference will focus on Diophantine Problems and Related topics and we propose that it connect with a CIMPA School to be held in Colombia. |

Institutions and scientific coordinators:

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## PDEGeInt - Nonlinear PDE’s and Geometry of Interfaces

Abstract:

The main topic of this project is the interplay between Nonlinear PDE’s and Nonlinear Analysis more in general, and the curvature-type properties of interfaces, vortices and measures. The project is structured into four directions, which have all links between each other. A first direction is that of using minimal and Willmore surface techniques for studying minimal surfaces in the hyperbolic space and in Poincare-Einstein manifolds, with an emphasis on controlling sequences of degenerating surfaces. A second direction is the study of Ginzburg-Landau vortex line concentration in superconductivity, and to understand the effect of pinning. Here again the vortices can be seen as a form of degeneration of the equations, whose disposition depends on the geometry of the domain.

A third direction is the study of Allen-Cahn equations in hyperbolic space, via the theory of minimal surfaces. Note that Allen-Cahn equations are a standard model for phase transitions, and they generate an interface of codimension 1 (as opposed to having dimension 1 as in the Ginzburg- Landau vortex line mode), which behaves similarly to a minimal surface. The fourth direction is that of progressing the study of uniform measures. These are very symmetric measures in Euclidean space, which appear at the core of the main rectifiability results in Geometric Measure Theory. The general classification of such measures is open, and we will be studying the case of 1 and 2 dimensional measures, which are curves and surfaces of “constant curvature” in a generalized sense.

Institutions and scientific coordinators:

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## SOCCAE - Stochastic Optimization and Chance Constraints with Applications to Energy

Abstract:

In most south American countries, like Chile and Peru, and also in European countries as France, the dispatch of electrical power in the electrical market is regulated by a centralized entity, usually called the Independent System Operator (ISO) The objective of this regulator is to satisfy the demand of the electrical network while minimizing the cost of production. The introduction of unconventional renewable energies and new paradigms as distributed generation, forces the ISO to treat its optimization processes by including randomness in its models. The main goal of this project is to treat two of the ISO problems, namely the dispatch problem and the network design problem, which can be modeled as bilevel games. To do so, we will further develop two tools in stochastic optimization: chance constraints, which are very relevant in network planning, and stochastic quasi-variational inequalities, which are known to be first order optimality conditions in stochastic optimization problems like the dispatch problem mentioned above. We intent to use these developments to propose new models and algorithms to address part of the new challenges presented by the modern context in energy systems.

Institutions and scientific coordinators:

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## STALGRAPH - Structural and algorithmic graph theory

Abstract:

The mathematical questions we plan to investigate in this project all belong to structural and algorithmic graph theory. The first focus is on coloring complexity of graphs with certain excluded induced subgraphs. The question is whether k-coloring becomes easier if we only consider a class of graphs characterized by forbidden induced subgraphs. If only one subgraph is forbidden, then almost all complexities have been determined, the only open cases are when the forbidden induced subgraph is a linear forest. These open cases seem to be hard to solve in general, but if we forbid another subgraph, or if we consider approximate colorings, the problem might become more accessible, and this is what we propose to study. The second focus is on graphs decompositions, in particular we will work on Gallai's Conjecture and Hajós’ Conjecture for restricted classes of graphs, in order to develop techniques that may show useful to prove (or disprove), respectively, either conjecture. The third focus is on Kneser graphs. Kneser graphs model intersecting set families of set

systems. We plan to investigate several structural properties of Kneser graphs. In particular, we will study s-stable Kneser graphs and their relation to cores. We are also interested in Caratheodory, Helly and Radon numbers of Kneser graphs (all of these parameters are related to a given convexity in a graph) and in Hamiltonicity of Kneser graphs.

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