

# **Journées de lancement de la fédération OcciMath**

## **Rapport sur les contributions**

ID de Contribution: **1**

Type: **Non spécifié**

## **Lancement de la Fédération**

*jeudi 4 avril 2024 13:30 (1 heure)*

ID de Contribution: 2

Type: **Non spécifié**

## The schematization problem

*jeudi 4 avril 2024 14:30 (1 heure)*

In his manuscript “Pursuing stacks”, Grothendieck mentions a certain “schematization problem”, which is a far reaching extension of the rational homotopy theory of Quillen and Sullivan. In this talk, I will explain the schematization problem, and present several progress , applications and open questions.

**Orateur:** TOËN, Bertrand (IMT, CNRS & UPS - Toulouse 3)

ID de Contribution: 3

Type: **Non spécifié**

## **Stable solutions to semilinear elliptic equations are smooth up to dimension 9**

*jeudi 4 avril 2024 16:00 (1 heure)*

The regularity of stable solutions to semilinear elliptic PDEs has been studied since the 1970's. It was initiated by a work of Crandall and Rabinowitz, motivated by the Gelfand problem in combustion theory. The theory experienced a revival in the mid-nineties after new progress made by Brezis and collaborators. I will present these developments and my work in collaboration with Figalli, Ros-Oton, and Serra, which finally establishes the regularity of stable solutions up to the optimal dimension 9. I will also describe a more recent paper of mine which provides full quantitative proofs of the regularity results. I will finally comment on similar progress and open problems for related equations.

**Orateur:** CABRÉ, Xavier (ICREA, UPC- Barcelona)

ID de Contribution: 4

Type: **Non spécifié**

## Structure-preserving discretization of incompressible MHD systems

*jeudi 4 avril 2024 17:00 (1 heure)*

The magnetohydrodynamics (MHD) systems have several important conservative properties, e.g., the magnetic Gauss law and the conservation of energy and (magnetic, cross, hybrid) helicity in the ideal limit. These conserved quantities encode various kinds of intrinsic symmetry of the equations. To achieve physical fidelity and numerical stability, it is desirable to preserve these conditions precisely in the numerical discretization (up to the machine precision).

In this talk, we first review the conservative properties of continuous MHD systems and the idea of Finite Element Exterior Calculus. Then we construct finite element methods that precisely preserve these properties. Discrete de Rham sequences play a vital role in the study.

**Orateur:** HU, Kaibo (Maxwell Institute for Mathematical sciences, Univ Edinburgh)

ID de Contribution: 5

Type: **Non spécifié**

## Walks, difference equations and elliptic surfaces

*vendredi 5 avril 2024 09:00 (45 minutes)*

A walk in the quarter plane is a path in the lattice  $\mathbb{Z}^2$  with a prescribed set of directions that is confined in the quarter plane. In the recent years, the enumeration of such walks has attracted the attention of many authors in combinatorics and probability. The complexity of their enumeration is encoded in the algebraic nature of their associated generating series. The main questions are: are these series algebraic, holonomic (solutions of linear differential equations) or differentially algebraic (solutions of algebraic differential equations)?

In this talk, we will show how the algebraic nature of the generating series can be approached via the study of a discrete functional equation over a curve  $E$  of genus zero or one over a function field and the Galois theory of difference equations. In the genus zero case, the functional equation corresponds to a so called  $q$ -difference equation and the generating series is differentially transcendental. In genus one, the dynamic of the functional equation is the addition by a given point  $P$  of the elliptic curve  $E$ . If the point  $P$  is torsion then the generating series is holonomic. When  $P$  is non torsion, the nature of the generating series is captured by the linear dependence relations of certain prescribed points in the Mordell-Weil lattice of an elliptic surface.

**Orateur:** HARDOUIN, Charlotte (IMT, UPS - Toulouse 3)

ID de Contribution: 6

Type: **Non spécifié**

## Stochastic control for medical treatment optimization

*vendredi 5 avril 2024 09:45 (45 minutes)*

We are interested in monitoring patients in remission from cancer. Our aim is to detect their relapses as soon as possible, as well as detect the type of relapse, in order to decide on the appropriate treatment to be given. Available data are some marker level of the rate of cancerous cells in the blood which evolves continuously but is measured at discrete (long) intervals and through noise. The patient's state of health is modeled by a piecewise deterministic Markov process (PDMP). Several decisions must be taken from these incomplete observations: what treatment to give, and when to schedule the next medical visit. The results will be illustrated by simulations calibrated on a cohort of a clinical trial on multiple myeloma provided by the Center of Cancer Research in Toulouse.

This is a joint work with Alice Cleynen (IMAG), Orlane Rossini (IMAG), Régis Sabbadin (Inrae MIAT) Aymar Thierry d'Argenlieu (IP Paris), Amélie Vernay (IMAG) within ANR HSMM-INCA

**Orateur:** DE SAPORTA, Benoîte (IMAG, Univ Montpellier)

ID de Contribution: 7

Type: **Non spécifié**

## On the stability of the Möbius group of the n-sphere

*vendredi 5 avril 2024 11:00 (45 minutes)*

A classical theorem of Liouville asserts that if a map from the sphere to itself is conformal, then it must be a Möbius map: a composition of dilations, rotations, inversions and translations (identifying sphere and euclidean space via stereographic projection). There is a long history of studying stability of this rigidity statement: if a map is nearly conformal, must it be close to a Möbius transform? One can also ask what happens if the image of the map is only nearly spherical. I will present sharp stability estimates obtained recently with André Guerra and Kostantinos Zemas.

**Orateur:** LAMY, Xavier (IMT, UPS - Toulouse 3)



ID de Contribution: 8

Type: **Non spécifié**

## **Contribution of optimal control to decision support in crop irrigation**

*vendredi 5 avril 2024 11:45 (45 minutes)*

Faced with water scarcity, crop irrigation needs to optimize water inputs over a season, to ensure crop production under both water and nitrogen stress. We study several optimal control problems on a reduced crop model, which allow us to characterize policy structures that can be tested on more complex models or in the field.

In particular, we show the role of non-autonomous and non-smooth dynamics in these problems.

**Orateur:** RAPAPORT, Alain (MISTEA, Dpt Maths INRAE)

ID de Contribution: 9

Type: **Non spécifié**

## On the Burau representation of braids

*vendredi 5 avril 2024 14:15 (45 minutes)*

The Burau representation of braid groups goes back to the thirties, and can be defined by assigning to each generator an explicit matrix. Despite this very easy definition, it is still an open question whether or not the representation is faithful in the 4-strand case (faithfulness in the 3-strand case is an old result, and counterexamples for 5 strands were found by Bigelow in 1999). I'll try to explain why I find this question tantalizing, and advertise related (easier?) open problems.

**Orateur:** QUEFFELEC, Hoel (IMAG, CNRS & Univ Montpellier)

ID de Contribution: 10

Type: **Non spécifié**

## Feature selection for kernel methods in systems biology

*vendredi 5 avril 2024 15:00 (45 minutes)*

The substantial development of high-throughput bio-technologies has rendered large-scale multi-omics datasets increasingly available. New challenges have emerged to process and integrate this large volume of information, often obtained from widely heterogeneous sources. Kernel methods have proven successful to handle the analysis of different types of datasets obtained on the same individuals. However, they usually suffer from a lack of interpretability since the original description of the individuals is lost due to the kernel embedding. We propose novel feature selection methods that are adapted to the kernel framework and go beyond the well established work in supervised learning by addressing the more difficult tasks of unsupervised learning and kernel output learning. The method is expressed under the form of a non-convex optimization problem with a l1 penalty, which is solved with a proximal gradient descent approach. It is tested on several systems biology datasets and shows good performances in selecting relevant and less redundant features compared to existing alternatives. It also proved relevant for identifying important governmental measures best explaining the time series of Covid-19 reproducing number evolution during the first months of 2020.

**Orateur:** BROUARD, Céline (MIAT, Dpt Maths INRAE)

ID de Contribution: 11

Type: **Non spécifié**

## Mathematical Modelling in Contact Mechanics

*vendredi 5 avril 2024 15:45 (45 minutes)*

Contact phenomena between deformable bodies abound in industry and everyday life. A few simple examples are brake pads in contact with wheels, tires on roads, and pistons with skirts. Because of the importance of contact processes in structural and mechanical systems, considerable effort has been put into their modeling, analysis and numerical simulations and, consequently, the Mathematical Theory of Contact Mechanics (MTCM) has undergone a great development, especially in the last decades.

The aim of this lecture is to present an introduction to the MTCM. Thus, we present various mathematical models which describe the contact of elastic or viscoelastic materials with a rigid or deformable foundation. We show how these models lead to nonsmooth problems, expressed in terms of variational and hemivariational inequalities, inclusions or sweeping processes, for which we present existence, uniqueness, convergence and well-posedness results. We complete our presentation with numerical simulations and mechanical interpretations

**Orateur:** SOFONEA, Mircea (LAMPS, Univ Perpignan Via Domitia)