III Simposio sobre Ecuaciones Diferenciales Parciales y Teoría de Números

13 al 16 de octubre de 2025

Centro de Modelamiento Matemático
Facultad de Ciencias Físicas y Matemáticas
Universidad de Chile

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UNIVERSIDAD DE CHILE

Universidad Austral de Chile
Conocimiento y Naturaleza

Universidad de O'Higgins

25 años CMM Centro de Modelamiento Matemático

Agencia Nacional de Investigación y Desarrollo
Ministerio de Ciencia, Tecnología, Conocimiento e Innovación
Gobierno de Chile

Full information can be found at: III Simposio EDPs & TN

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About

III Simposio EDPs y TN

The III Simposio sobre Ecuaciones Diferenciales Parciales y Teoría de Números is envisioned as a collaborative space where participants will have the opportunity to engage with recent advances and explore emerging research directions. We have designed this event not only as a platform to disseminate knowledge, but also as a space to foster intellectual exchange, encourage collaborative dialogue, and promote research collaborations that may contribute to the advancement of physics, partial differential equations (PDEs), and number theory — the core areas this symposium aims to encompass.

Partner Institutions and Sponsors

The series of Symposia on Partial Differential Equations (PDE) and Number Theory (NT) was started in 2023 as an interdisciplinary space that seeks to foster dialogue and collaboration between researchers in these two fundamental areas of mathematics.

Initially organized by the Universidad Austral de Chile and the Universidad de Chile, with the support of the **ANID Exploration** project 13220060, *"**The PDE approach in two number theoretical monster problems**"*, these meetings have established themselves as a platform to explore new connections and promote research networks in the region. Each edition has brought together academics, young researchers and students around talks, workshops and scientific activities that address problems at the border between PDEs and NT, such as the connections between PDEs and the unsolved enigmas of the Riemann zeta function and the Collatz conjecture.

This year, the Universidad de Chile, together with the Universidad Austral de Chile and the Universidad de O'Higgins, in the framework of the ANID Exploration project *"The PDE approach in two number theoretical monster problems"*, organize the Third Symposium on Partial Differential Equations (PDE) and Number Theory (NT).

The third edition takes place at the Center for Mathematical Modeling of the University of Chile, October 13-16, 2025, and counts for the first time with the University of O'Higgins as co-organizing institution.

Scientific committee

Marco Bianchi, research professor at the University of San Sebastian. Theoretical physicist specialized in High Energy Physics.

Felipe Gonçalves, professor at IMPA / University of Texas at Austin. Researcher specializing in Analysis and Number theory, topics such as packings, uncertainty principles, among others.

Amalia Pizarro, professor at the Institute of Mathematics of the Universidad de Valparaíso. Researcher specializing in Number Theory and Cryptography.

Felipe Poblete, professor at Institute of Physical and Mathematical Sciences, University Austral of Chile. Researcher specializing in Dispersive Partial Differential Equations, theory of semigroups, and resolvent families of Evolution Equations.

Organizing committee

Claudio Muñoz, professor at Department of Mathematical Engineering, Universidad de Chile. Researcher specializing in Nonlinear Dispersive Equations, in particular: collisions, well-posedness, stability and asymptotic stability of kinks and solitons.

Juan Carlos Pozo, professor at the Institute of Engineering Sciences of the University of O'Higgins. Researcher specializing in the study of equations in partial derivatives and in the dynamic properties of their solutions.

Jessica Trespalacios, ANID postdoc researcher at Universidad Austral de Chile. Researcher specializing in the mathematical study of Einstein's field equations in a vacuum, cosmological solutions, and their stability.

María Eugenia Martínez, professor at the Department of Mathematical Engineering, Universidad de Chile. Researcher specializing in the study of long-time behavior of solutions, decay properties, solitons and collisions for Schrödinger-type equations and water waves models.

Ricardo Freire, ANID postdoc researcher at the Universidad de Chile. Researcher specializing in Nonlinear Dispersive equations and the relation between the dispersion and topics in Harmonic Analysis.

Timetable

CS: Cursillo Session, **IS**: Invited Speaker, **PS**: Posters Session.

Monday, 13th Otober

8:30–8:50	**Registration & opening**		
8:50–9:00	**Welcome remarks**		
9:00–10:00	CS	**F. Gonçalves** IMPA/ University of Texas	Montgomery's Pair-Correlation Conjecture
10:00–10:30	**Coffee**		
10:30–11:30	IS	**A. Dobner** University of Michigan	Alternative random models of the zeros of the Riemann zeta function
11:30–12:30	IS	**J. Bober** University of Bristol	Mixed character sums and extremal properties of Littlewood polynomials
12:30–14:30	**Lunch**		
14:30–15:30	IS	**J. van Order** Pontificia Universidade Católica do Rio de Janeiro	New approaches to the shifted convolution problem for $GL(n)$
15:30–16:00	**Coffee**		
16:00–17:00	IS	**C. A. Chirre** Pontificia Universidad Católica del Perú	Bounds for the partial sums of the Möbius function and extremal functions

Tuesday, 14th Otober

9:00–10:00	CS	**M. Espinoza** Universidad de la Serena	Special Values of Generalized Dirichlet L-functions
10:00–10:30	**Coffee**		
10:30–11:30	CS	**F. Gonçalves** IMPA / University of Texas at Austin	Montgomery's Pair-Correlation Conjecture
11:30–12:30	IS	**C. González-Riquelme** Centro de Recerca Matemática	Maximizers of extension inequalities for quadratic surfaces in finite fields
12:30–14:30	**Lunch**		
14:30–15:30	IS	**O. Klurman** University of Bristol (UK)	Counting sign changes
15:30–16:00	**Coffee**		
16:00-17:00	IS	**J. Van Diejen** Universidad de Talca	Elementary hypergeometric functions, the dynamics of zeros, and KdV solitons

Wednesday, 15th Otober

9:00–10:00	CS	**F. Gonçalves** IMPA/ University of Texas at Austin	Montgomery's Pair-Correlation Conjecture
10:00–10:30	**Coffee**		
10:30–11:30	CS	**M. Espinoza** Universidad de la Serena	Special Values of Generalized Dirichlet L-functions
11:30–12:30	IS	**E. Carneiro** The Abdus Salam International Centre for Theoretical Physics	Fractional derivatives and the equidistribution of Galois orbits
12:30–14:30	**Lunch**		
14:30–15:30	IS	**H. Van Den Bosch** Universidad de Chile	Spectral flow methods for edge states at soft walls
15:30–16:00	**Coffee**		
16:00-17:00	IS	**N. Valenzuela** Universidad de Chile	An Introduction to Physics Informed Neural Networks and Their Application to Nonlinear Dispersive Equations
17:30–	**Event Dinner**		

Thursday, 16th Otober

9:00–10:00	CS	**M. Espinoza** Universidad de la Serena	Special Values of Generalized Dirichlet L-functions
10:00–10:30	**Coffee**		
10:30–11:30	PS	**Posters**	Presentations
11:30–12:30	IS	**L. Lomelí** Pontificia Universidad Católica de Valparaíso	Automorphic L-functions and Ramanujan Conjecture
12:30–14:30	**Lunch**		
14:30	**Free**		

List of Abstracts – Cursillos

Special Values of Generalized Dirichlet L-functions

Milton Espinoza CS

Universidad de La Serena (Chile)

This short course aims to introduce avatars of Dirichlet L-functions in higher dimensions, as well as to describe a method for explicitly computing their special values at non-positive integers (and also at positive integers when the corresponding functional equation allows it). Tackling the multiplicity of dimensions requires a delicate interplay of ideas from algebra, analysis, geometry, and topology. The epiphany occurred in the late 1970s and is owed to the Japanese mathematician Takuro Shintani, who ultimately discovered how to generalize Riemann's first proof of the analytic continuation of the zeta function to certain multivariable Dirichlet series. The main results from number theory that we will use will be presented throughout the course.

Montgomery's Pair-Correlation Conjecture

Felipe Gonçalves CS

IMPA (Brazil) / University of Texas (USA)

In this series of lectures we will try to provide, as much as possible, all the necessary background to understand Montgomery's Pair-Correlation Conjecture about the zeros of the zeta-function and its relations of random matrix models.

In the end, we will try to present recent advancements in this topic related to certain optimization problems.

List of Abstracts – Talks

Monday 13th

Alternative random models of the zeros of the Riemann zeta function

Timeline: 10:30 - 11:30

Alexander Dobner

IS

University of Michigan (USA)

There is a great deal of numerical evidence suggesting that the zeros of the Riemann zeta function "look like" the eigenvalues of a random unitary matrix. This empirical connection between number theory and random matrix theory has enabled number theorists to make precise conjectures about the Riemann zeta function. However, there is still a large gap between what has been conjectured and what is known rigorously. To test the limitations of our current knowledge, it is interesting to ask whether there are other random models of the zeta zeros that are consistent with what is known rigorously. One such model called ACUE was recently proposed by Tao and independently by Lagarias and Rodgers. I will discuss this strange 'alternative' model of the zeta zeros, and give some new results about it.

Mixed character sums and extremal properties of Littlewood polynomials

Timeline: 11:30 - 12:30

Jonathan Bober

IS

University of Bristol (UK)

I will discuss questions and results about the distribution of sums of Dirichlet characters times the exponential function. Studying these questions for quadratic characters leads to new record constructions of polynomials with +/- 1 coefficients and large Mahler measure. This is joint work with Oleksiy Klurman and Besfort Shala.

New approaches to the shifted convolution problem for $GL(n)$

Timeline 14:30 - 15:30

Jeanine Van Order

IS

Pontifícia Universidade Católica do Rio de Janeiro (Brazil)

I will survey the shifted convolution problem for $GL(n)$ L-function coefficients, then describe an approach showing the analytic continuation of the underlying Dirichlet series using variation of vectors in Kirillov models. This is based on work in progress with Dorian Goldfeld.

Bounds for the partial sums of the Möbius function and extremal functions

Timeline 16:00 - 17:00

Carlos Andrés Chirre IS

Pontificia Universidad Católica del Perú (Peru)

One of my favorite quotations in Mathematics is from Titchmarsh, who remarked: "The finer theory of the partial sums of the Möbius function is extremely obscure, and the results are not nearly so precise as the corresponding ones in the prime number problem." In this talk, we will show how certain extremal functions in Fourier analysis can be employed to obtain good bounds for the partial sums of the Möbius function.

Tuesday 14th

Maximizers of extension inequalities for quadratic surfaces in finite fields

Timeline 11:30 - 12:30

Cristian González-Riquelme IS

Centro de Recerca Matemática (Spain)

Strichartz estimates are important inequalities in PDEs. There is a correspondence between them and Fourier extension inequalities for quadratic manifolds. On the other hand, since the work of Mockenhaupt and Tao, much effort has been made in order to establish the finite field analogues for these Fourier extension inequalities. In this case, the arithmetic structure of these spaces plays a major role. In this talk, we present optimal versions of these inequalities in this setup. This is based on joint works with Diogo Oliveira e Silva and Tolibjon Ismoilov.

Counting sign changes

Timeline 14:30- 15:30

Oleksiy Klurman IS

University of Bristol (UK)

The aim of this talk is to discuss a simple way producing sign changes of weighted multiplicative sums. We illustrate its applicability by studying the number of sign changes of partial sums of «typical» real Dirichlet characters and random multiplicative functions, uncovering some surprising phenomena.

Elementary hypergeometric functions, the dynamics of zeros, and KdV solitons

Timeline: 16:00 - 17:00

Jan Felipe van Diejen IS

Universidad de Talca (Chile)

It is well-known that the one-dimensional stationary Schrödinger equation with a Pöschl-Teller potential can be solved exactly by means of Gauss' hypergeometric series. For special values of the coupling constants such that the potential becomes reflectioness, this hypergeometric series factorizes essentially in terms of a plane wave and a polynomial in the spectral parameter. We point out that the positions of the zeros of this polynomial satisfy an integrable Hamiltonian system of differential equations in the spatial variable. Integration of the pertinent Hamiltonian dynamics gives rise to detailed insight into the zeros of the reflectionless hypergeometric series. Moreover, the Pöschl-Teller potential can be reconstructed from the positions of the zeros in question. By acting with a time-flow generated by a second integral of the Hamiltonian system for the zeros, the KdV solitons are recovered.

Wednesday 15th

Fractional derivatives and the equidistribution of Galois orbits

Timeline 11:30 - 12:30

Emanuel Carneiro IS

The Abdus Salam International Center for Theoretical Physics (Italy)

In this talk I will discuss effective versions of the celebrated Bilu's equidistribution theorem for Galois orbits of sequences of points of small height, identifying the qualitative dependence of the convergence in terms of the regularity of the test functions considered. I will present a general Fourier analysis framework that extends previous results in the literature. This is based in a joint work with Mithun Das (ICTP).

A Spectral flow methods for edge states at soft walls

Timeline 14:30 - 15:30

Hanne Van den Bosch IS

Universidad de Chile (Chile)

The goal of this work is to understand the appearance of edge states in models from solid state physics. I will give a general introduction to the concept of spectral flow and its properties that allow us to estimate when these edge modes appear. The talk is based on joint work with David Gontier.

An Introduction to Physics Informed Neural Networks and Their Application to Nonlinear Dispersive Equations

Timeline: 16:00 - 17:00

Nicolás Valenzuela IS

Universidad de Chile (Chile)

In recent years, Deep Learning (DL) techniques have emerged as powerful tools for approximating solutions to certain partial differential equations (PDEs). Most applications to date focus on bounded domains, due the capability of traditional numerical methods. In this talk, we introduce a novel approach that combines Physics Informed Neural Networks (PINNs) -a recently developed DL framework- with stability theory to approximate solutions of nonlinear dispersive equations posed on unbounded domains. We specifically explore the effectiveness of PINNs in addressing the nonlinear Schrödinger and generalized Korteweg-de Vries (gKdV) equations, highlighting how this method can be employed in the absence of boundary conditions.

Thursday 16th

Automorphic L-functions and Ramanujan Conjecture

Timeline: 11:30 - 12:30

Luis Lomelí IS

Pontificia Universidad Católica de Valparaíso (Chile)

The Langlands Program ecompasses general reciprocity laws and the principle of functoriality that interconnect several areas of mathematics, including Number Theory, Representation Theory and Geometry. Our approach is via L-functions associated to automorphic representations of a group of Lie type over a global field. We will discuss the axioms of a theory of L-functions and a holomorphy property for cuspidal representations. We will then approach Langlands functoriality and the Ramanujan Conjecture, having in mind the example of groups of classical kind. In particular, the Ramanujan Conjecture can be reduced to the general linear group via functoriality. Note that in the particular case of a global function field, thanks to the work of Laurent Lafforgue, this is a known result for $GL(n)$. We will say a few words about the general progress around these important problems of current mathematical research.

List of Posters

A note on two flows of Collatz evolution

PS

Francisco Alegría, *Universidad Austral de Chile*

In this presentation, we will focus on two evolution models based on the generalized Collatz operator. In general, the first evolution model is a continuum, defined through Fourier, motivated by Gérard and Grellier's cubic Szego operator. The second evolution model considers discrete temporal derivatives of Collatz orbits. In this work, we describe the evolution of both models, with special emphasis on dynamic properties. First, we demonstrate local and global existence in the $L^2(T)$ space, as well as a bijective characterization of the existence of non-trivial periodic and unbounded orbits of the Collatz mapping in terms of a particular set of solutions of this continuous Collatz flow. For the discrete part, a kind of discrete energy is introduced. This energy is conserved by the discrete flow. An estimate of each term in this energy will be given, proving appropriate growth bounds. Finally, the meaning of the discrete time derivative for generalized Collatz orbits is discussed.

Dynamical Prime Number Theorem

PS

Diego Céspedes, *Universidad de Chile*

Building on the previous work of Bergelson-Richter, Loyd, and Burgin. We propose a dynamical systems formulation of the Prime Number Theorem for number fields. We present new ergodic theorems that have applications to dynamics and number theory, which are of independent interest.

Bounding zeta at the line $\mathrm{Re}\, s = 1$

PS

Blas Salvador Molero Ravines, *Pontificia Universidad Católica del Perú*

Assuming the Riemann Hypothesis, we establish explicit bounds for the real part of the logarithmic derivative of the Riemann zeta function on the line $\mathrm{Re}\, s = 1$, using bandlimited approximations of the Poisson kernel. These bounds enable us to refine previous results of Lamzouri, Li, and Soundararajan concerning explicit upper and lower estimates for $|\zeta(1 + it)|$, valid for all $t \geq 2.8 \cdot 10^7$.

Construction of stellar atmospheres models throught the use of PINNs PS

Álvaro Márquez Sandoval, *Universidad de Chile*

In astrophysics, one of the main topics is the study of the formation and evolution of galaxies. There are different ways to address this topic, one being studying in detail a particular Galaxy, for example, the Milky way, down to star by star, issue that can be address through the analysis of the spectrum of the star. One of the ingredients needed to do spectroscopy analysis are numerical models that describe the thermody- namic structure of the atmospheres of the stars. Nowadays there are models used for analysis such as MARCS, ATLAS or PHOENIX, developed through the use of numerical methods, but these have some 'issues': i) There are models only for a grid of the whole space of parameters, leading to the use of interpolation methods that don't follow the physics of the models, ii) Due to convergence problems of the numerical methods, there are areas in the space of parameters that have just a few models. Here we present the first step towards the solution of those problems. We present an application of Physics- Informed-NeuralNetworks(PINN)togeneratenumericalmodelsofstellaratmospheresforacertaincombination of parameters under assumptions of Local Thermodynamical Equilibrium (LTE) and 1-dimensional models. To fullfill our objective we will implement the use of PINNs to solve the chemical equilibrium given a certain combination of chemical abundances and the transfer equation given a temperatura and an optical detph, to end up with information to generate the model of the desired stellar atmosphere.

The Generalized Riemann Zeta Heat Flow PS

Vicente Salinas, *Universidad de Chile*

We study PDE flows associated with the Riemann zeta function and Dirichlet L-functions. These models feature nonlinearities arising from number theory and generalize the classical holomorphic Riemann flow of Broughan and Barnett. We establish results on local and global existence, prove blow-up phenomena in the focusing case, and analyze the asymptotic stability of solutions near zeros of L-functions.

The Holomorphic Flow of Dirichlet's Beta PS

Francisco Fernández, *Universidad de Chile*

Following Broughan's results for Riemann's xi function, we study the symmetrization of Dirichlet's beta function and, in particular, the separatrices of its holomorphic flow. We prove the existence of separatrices and their convergence. We also studied their crossings with the critical line. Showing that, under reasonable assumptions, there is a sequence of these crossings that relates to the zeroes on the critical line.

Study of the solitons of the KP-II equation

PS

Benjamín Tardy D., *Universidad Austral de Chile*

This work explores soliton and multi-soliton solutions of the KP-II equation. The study seeks to find conditions that allow these types of solutions to be characterized. To do this, the solutions are expressed by means of a profile and a phase, with phases defined by sums of exponentials. The study restructures the terms of the KP-II equation in terms of these two new parameters, seeking to appreciate the structures inherent in the solutions. In the process, four operators are defined that characterize the phases and one operator to describe a differential equation on the profile, in order to study its characteristics. Three types of solutions are characterized: line soliton, resonant multi-soliton, and 2-soliton. In this work, the profile is fixed, and the types of solutions are distinguished by the phases used in their construction. This advance makes it possible to predict the structure of the solutions according to the phase and profile, as well as to identify the phases that generate a specific type of solution.

Cooperation on continuous structured populations

PS

Matías Neto , *Universidad de Chile*

The role of cooperation in evolutionary studies has often been underestimated, despite the abundant evidence in nature of its importance [sachs'04/Q. Rev. Biol]. We study an integro-differential logistic selection model that describes the evolution of a structured population with respect to a quantitative trait $y \in Y$. The set of traits Y is a compact interval of R, and the ecological time scale is $t > 0$. The model is given by the following equation:

$$\frac{\partial f}{\partial t} = s[f]f = \left(a(y) - \int_Y b(y,y')f(y')\,dy'\right) f, \tag{0.1}$$

where $s[f]$ denotes the fitness of trait y in the population f, $a : Y \to R$ is the birth rate, and $b : Y \times Y \to R$ is the interaction kernel between traits.

According to adaptive dynamics, studying the asymptotic behavior of this model corresponds to identifying an Evolutionary Stable Distribution (ESD). ESDs have been analyzed for continuous sets of traits; for example, [Desvilletes'08/C.Math.S] focused on the case $\inf_{y,y' \in Y} b(y,y') > 0$, the purely competitive case, proving existence and stability results for ESDs. For the competitive case, [Jabin'11/J. Mat. Bio.] proved convergence to an ESD.

In this work, we extend the selection dynamics framework for continuously structured populations by allowing cooperative interactions. We prove existence results for solutions, characterize long-term fitness properties, and establish convergence to a unique ESD. Numerical simulations show that, under symmetric interactions, if the birth rate is constant, the selected traits are the cooperative ones, whereas if the birth rate varies, a trade-off emerges between the kernel and the birth rate in determining the selected ESD. Moreover, cases of overyielding are observed, and the dynamics under non-symmetric selection are also investigated.

List of Participants

Name	Affiliation
Ignacio Acevedo	Université Paris-Saclay
Francisco Alegría	Universidad Austral de Chile
Rodrigo Altamirano	Universidad de Chile
Diergo Aravena	Universidad austral de Chile
Marco Bianchi	Universidad de San Sebastián
Jonathan Bober	University of Bristol
Rayssa Caju	Universidad de Chile
Emanuel Carneiro	The Abdus Salam International Centre for Theoretical Physics
Carlos Andrés Chirre	Pontificia Universidad Catolica del Perú
Diego Céspedes	Universidad de Chile
Luis Antonio Cortés-Vega	Universidad de Antofagasta
Alexander Dobner	University of Michigan
Sebastián Donoso	Universidad de Chile
Milton Espinoza	Universidad de La Serena
Francisco Fernández	Universidad de Chile
Rodrigo Fernández	Universidad Austral de Chile
Eduardo Friedman	Universidad de Chile
Ricardo Freire	Universidad de Chile
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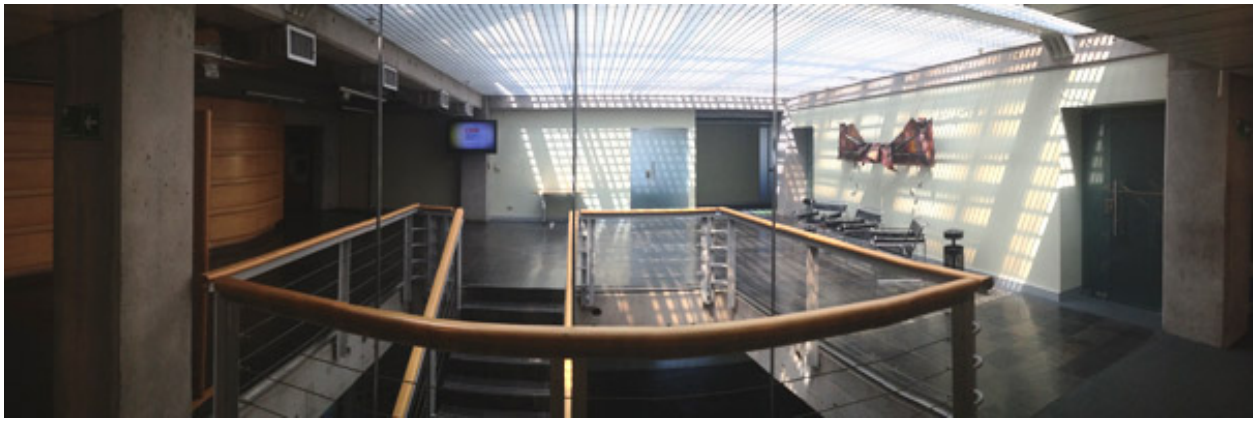
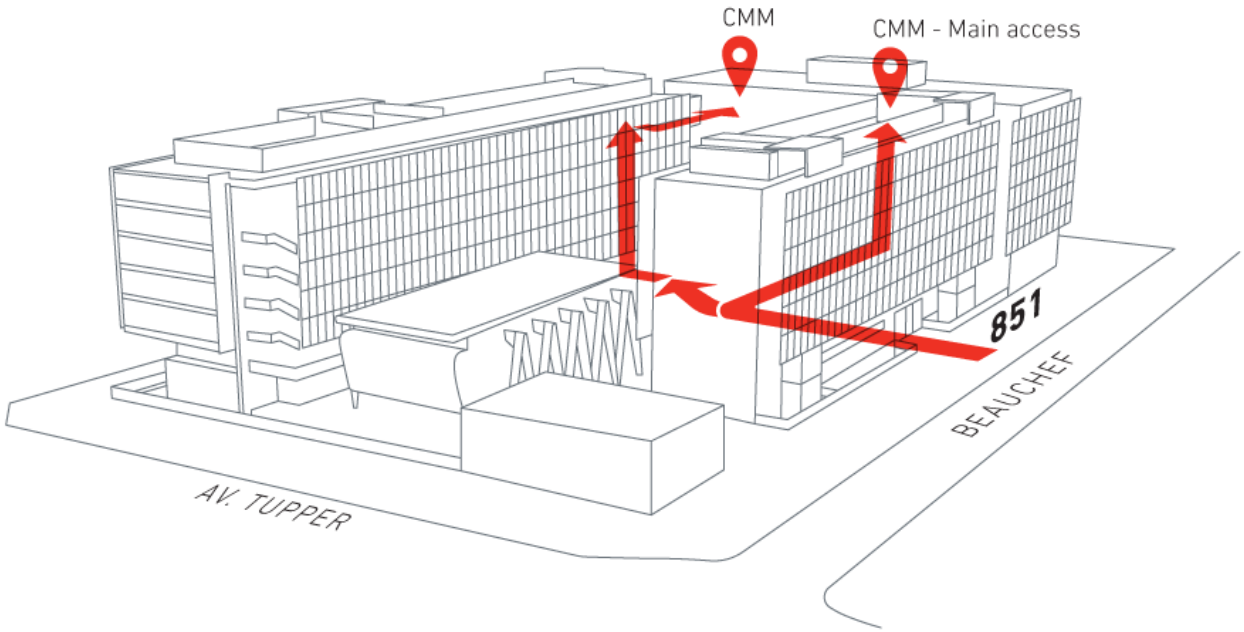
Hanne Van Den Bosch	Universidad de Chile
Jan Felipe Van Diejen	Universidad de Talca
Jeanine Van Order	Pontifícia Universidade Católica do Río de Janeiro
Nicolás Valenzuela	Universidad de Chile
Leonardo Varas	Universidad Santiago de Chile
Lucas Villagran	Universidad de Chile

Useful Information

The event wiil be held in the **John von Neumann Seminar Room** of the Center for Mathematical Modeling at the Faculty of Physical and Mathematical Sciences, Universidad de Chile, located in Beauchef 851, Santiago.



Sala de Seminarios John von Neumann, Centro de Modelamiento Matemático (CMM).
Facultad de Ciencias Fśicas y Matemáticas (FCFM), Universidad de Chile.
Beauchef 851, Edificio Norte, piso 7 (7th floor).
Santiago, Chile.



Coffee breaks will be offered in main entrance of the conference hall.

Wi-Fi will be available during the conference. The CMM also provides access to an eduroam network.

How to get to the CMM?

Direction:

- **Subway:** Line L2 (yellow line), station Toesca.