Sacha Cardonna

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Current position

Ph.D. candidate in Mathematics.   *10/2023 - Present*
Institut Montpelliérain Alexander Grothendieck − Montpellier, France.
Title. Numerical study of free-border problem and wave-structure interaction.
Advisors. François Vilar & Fabien Marche.
Funding. French ministry fellowship, ranked 1st at I2S Doctoral School admission exam.

Research interests

Models.	*Numerics.*	*Applications.*	*Scientific computing.*
Conservation laws,	DG & FV methods,	Fluid mechanics,	O.-O. programming,
Hyperbolic systems,	Well-balanced schemes,	Nonlinear Shallow-Water,	Generical programming,
Models coupling.	ALE approaches.	Dispersive PDEs.	Parallel computing.

Education

Graduate studies in Mathematics.   *09/2020 - 06/2023*
Faculty of Sciences − Montpellier, France.
Master's Degree in Theoretical and Numerical Analysis of PDEs (*highest honours*).
Master's Degree in Fundamental Mathematics.
Highlights. 1st in Theoretical Analysis, Numerical Analysis, Research Traineeship, a Posteriori Estimates courses.
Rank. Valedictorian (GPA: 4.0).

Undergraduate studies in Mathematics & Physics.   *09/2017 - 05/2020*
Faculty of Sciences − Montpellier, France.
Bachelor's Degree in Pure and Applied Mathematics (*first-class honours*).
Associate's Degree in Mathematics & Physics (*first-class honours*).
Highlights. 1st in Numerical Analysis of ODEs, Convex Optimization & Classical Mechanics courses.
Rank. Consistently ranked in the top 10% best students (GPA: 3.7).

Work experiences

Ph.D. candidate in Mathematics.   *10/2023 - Present*
Institut Montpelliérain Alexander Grothendieck − Montpellier, France.

Teaching assistant at Department of Mathematics.   *10/2023 - Present*
Faculty of Sciences & Engineering School Polytech − Montpellier, France.

Research intern.   *03 - 07/2023*
Institut Montpelliérain Alexander Grothendieck − Montpellier, France.

Private tutor in Sciences.   *07/2017 - 05/2023*
Face-to-face and remote courses − Salon-de-Provence & Montpellier, France.

Teaching activities

Differential calculus & multivariable integration (2nd year B.Sc.)   *2023 - 2024*
Engineering School Polytech − Montpellier, France.
Role. Tutorial classes, coding, exam writing and marking.
Topics. Differential calculus, multivariable integration, topology, bilinear algebra.

Supervised mathematical assignments (2nd year B.Sc.)   *2023 - 2024*
Engineering School Polytech − Montpellier, France.
Role. Supervising various groups of students to prepare midterms and exams.
Topics. Differential calculus, multivariable integration, topology, bilinear algebra.

Grants

Competition of *Informations, Structures, Systèmes* (I2S) Doctoral School. *2023*
Highly selective admission exam to get Ph.D. scholarship from French Ministry of Research. Ranked 1st among all candidates in mathematics.
Funding. 125,500€ over 3 years.

Communications

Poster at Ph.D. Day. *03/2024*
Institut Montpelliérain Alexander Grothendieck − Montpellier, France.
Title. Monolithic DG-FV subcell convex property preserving scheme for Shallow Water.

Talk at Séminaire des Doctorants. *10/2023*
Institut Montpelliérain Alexander Grothendieck − Montpellier, France.
Title. Modeling, solving & implementing PDEs from waves-structure interactions.

Responsabilities

Student Representative of Master's Degree in Applied Mathematics. *2023 - 2024*
Representing students in various reunions of development council, in order to convey student comments and improve the formation.

Scientific diffusion

MATh.en.JEANS congress – Promoting mathematical research to high-schoolers. *05/2024*
Supervised by Louise Nyssen (IMAG & IRES) − Montpellier, France.
MATh.en.JEANS congress aims to introduce mathematics research to young students, under the leadership of a researcher and their teacher.

- Chain is based on volunteers (students, teachers, researchers), and is not graded. The twinning system allows students to explain and compare their ideas with those of a group of students who have worked on the same subject, in another establishment in the same city;

- Throughout France, more than 200 establishments host a MATh.en.JEANS workshop each year, the culmination being the presentation by students of the results of their work at a national conference.

Mathematics & Modeling – MathC2+ program. *04/2024*
Collaboration with IRES & IMAG − Montpellier, France.
Introducing applied mathematics, modeling and scientific computing to high-schoolers.

- Introducing some essential mathematics notions, followed by a hands-on activity measuring the free fall times of different objects, obtaining the motion equation as a second-degree polynomial;

- Discovering numerical root finding methods, highlighting their significance in physics and engineering, complemented by constructing mini catapults in order to explore physical principles for optimization, linking these to motion equations;

- Practicing Python programming, developping an analytical and numerical solver for the quadratic equation $ax^2 + bx + c = 0$, serving as the capstone project.

Introduction to Applied Mathematics – Supervision of 9th grade trainees. *12/2023*
Collaboration with IRES & IMAG − Montpellier, France.
Exploring the application of mathematics to real-world scenarios by examining two trains on a collision course, focusing on calculating their meeting point. This involves theoretical calculations of motion and numerical solutions via the bisection method, highlighting the intersection of mathematics, problem-solving, and programming.

Fête de la Science – Promoting scientific studies & professions. *10/2023*
With Benjamin Charlier (IMAG) & Tristan Xabada (L2C-CBS) − Lozère, France.
Visiting Peytavin & Saint-Pierre-Saint-Paul schools in order to promote mathematics professions, talk about our thesis subject and our student path with high schoolers.

Internships

Finite-Volume Subcells correction on discontinuous Galerkin schemes. *03 - 07/2023*
Building and implementing a new strategy for stabilizing discontinuous Galerkin numerical methods using a Finite-Volume subcells type approach for the Nonlinear Shallow-Water equations. We consider here an a priori approach, more precisely a monolithic subcell dG/FV convex property preserving scheme.
Advisors. François Vilar & Fabien Marche.

Asymptotic analysis of PDEs sequences and homogenization theory. *02 - 05/2022*
We consider two problems, including a Dirichlet problem on a variable open set. Ice fog forms when water vapour, mainly resulting from human activities, enters the atmosphere. This vapor condenses into droplets which quickly freeze, giving rise to particles of ice without a well-defined crystalline form. The objective is to model it as a homogenization problem.
Advisor. Michel Bellieud.

From differential geometry to mathematical billiards. *03 - 05/2021*
Studying one of the simplest dynamical system, the mathematical billiard where we characterize the periodic trajectories by their initial angle of shot.
Advisor. Daniel Massart.

Proof of Dirichlet Prime Number theorem. *01 - 04/2020*
Demonstrating that, for $a, b \in \mathbf{N}^*$, such that $\gcd(a, b) = 1$, the arithmetic progression $\{an + b\}_{n \in \mathbf{N}}$ contains an infinity of prime numbers. Such a proof needs various theories, like complex analysis or group theory.
Advisor. Sylvain Brochard.

Complementary training

Creative Pedagogy (Level 1&2). *01 - 03/2024*
The program enhances teaching by diversifying pedagogical approaches, promoting collaborative and engaging learning experiences, and incorporating creative and risk-taking methods.

- Focus on adapting teaching styles to various contexts, fostering interactivity, and developing collaborative projects;
- Aims to innovate the learning model to align with 21st-century challenges, strengthening academic and socio-economic ties.

Advisor. Céline Avenel & Alexander Arenas-Canon.

Advanced Programming for Scientific Computing. *10 - 12/2024*
High-level course based on C++ programming for scientific computing.

- Memory management, object-oriented programming concepts, and advanced data processing techniques for scientific research;
- Use of essential pre/post-processing tools in the context of complex scientific simulations;
- Emphasizes the importance of modern collaborative work tools, such as version control systems.

Advisor. Fabien Marche.

Management & Leadership. *01/2024*
The training aims at understanding the challenges of the managing function, having authority in our function and the adequate postures, as a manager, with different interlocutors.
Advisor. Audrey Agbodjogbe-Richard.

Research Ethics. *01 - 03/2023*
This MOOC training equips participants with a deep understanding of ethical principles in scientific research, emphasizing the significance of integrity, the impact of technological advancements, and the responsibilities of researchers and institutions. It delves into navigating conflicts of interest and values, preparing doctoral students, researchers, and citizens to address contemporary ethical challenges in science.
Reference establishment. Lyon's University.

Artificial Intelligence and Ethics. *12/2023*
This seminar explores the intersection of artificial intelligence technology and ethical considerations, examining the implications of AI on privacy, bias, and decision-making in society. It aims to equip participants with the knowledge to navigate the moral dilemmas posed by AI advancements, fostering responsible development and use of AI technologies.
Advisor. Laurent Fauré.

Scientific Writing & Publishing. *12/2023*

This MOOC training aims at being proficient in reading and analyzing scientific articles, understanding their structure, mastering the writing rules for each section, comprehending the peer-review process, and applying ethical guidelines in scientific writing.

Reference establishment. Institut de Recherche pour le Développement.

Computer skills

Programming	C/C++, Python, notions of Fortran.
Mathematics softwares	FreeFEM++, Matlab, Scilab, gnuplot, Maple, Mathematica.
Markup languages	HTML, CSS, PHP.
Typesetting systems	LaTeX, Beamer, Microsoft Office (*Word* & *PowerPoint*).
Operating systems	Linux (*Kali* & *Debian*), Windows, macOS.
Creation softwares	Adobe Creative Cloud, Audacity, Final Cut Pro X.

Projects

Hybrid High-Order method on Leray-Lions operators. *12/2022*

Advanced Numerical Analysis, introduction to Hybrid High-Order method course.

Studying a new non-conform finite-element method called Hybrid High-Order and its main discrete functional analysis results on Leray-Lions operators.

Advisor. Daniele Di Pietro.

Müller's SPH C++ implementation for fluid dynamics. *11/2022*

A Posteriori Estimates & Mesh Adaption course.

Building and implementing Smooth Particle Hydrodynamics method for a C++ simulation.

Advisor. Bijan Mohammadi.

Some results about measure theory. *05 - 09/2022*

Personal project lead during summer break.

Proving measure theory results, including differentiation of Radon measures, Besicovitch & Vitali covering theorems, Tietze & Lusin's theorems.

Advisor. Michel Bellieud.

Finite-element resolution and FreeFEM++ simulation. *05 - 04/2022*

Finite-Element method course.

Studying and implementing a Dirichlet problem with mixed boundary conditions on FreeFEM++.

Advisor. Vanessa Lleras.

Machine Learning code for database analysis. *10/2021*

Machine Learning & Convex Optimization course.

Database analysis and programming regression methods for machine learning on Python.

Advisor. Bijan Mohammadi.

Numerical interpolation and its limits. *2018*

Personal project lead during associate's degree.

Studying polynomial interpolation and Runge's phenomenon.

Advisor. Sylvain Brochard.

Courses taken

Fundamental courses. Theoretical Analysis of PDEs − Functional Analysis & Distribution Theory − Differential Geometry − Measure and Integration Theory − Complex Analysis − Topology of Metric Spaces − Galois Theory − Category Theory − Ring & Group Theory − Differential Equations & Calculus − Probability Theory − Euclidian Geometry − Linear & Bilinear Algebra − Real Analysis − Calculus.

Applied and specialized courses. Numerical Analysis of PDEs − Numerical Modeling − Homogenization for Navier-Stokes − Scientific Computing − Machine Learning & Convex Optimization − *A Posteriori* Estimates & Mesh Adaption − Fourier Transform & Convolution for Inverse Problems − Deterministic & Stochastic Modeling.

Physics courses. Solid & Fluid Mechanics − Electromagnetism − Electrostatics & Magnetostatics − Thermodynamics − Wave & Geometrical Optics − Electrohydrodynamics − Experimental Physics.

Languages

French (*native*), **English** (*fluent*), **Spanish** (*intermediate*).

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