

# SACHA CARDONNA

Email. cardonna.sacha@gmail.com Website. sachacardonna.github.io

## Current position

---

### Ph.D. candidate in Mathematics.

10/2023 - Present

*Institut Montpellierain 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 1<sup>st</sup> at I2S Doctoral School admission exam.

## Research interests

---

### *Models.*

Conservation laws,  
Hyperbolic systems,  
Models coupling.

### *Numerics.*

DG & FV methods,  
Well-balanced schemes,  
ALE approaches.

### *Applications.*

Fluid mechanics,  
Nonlinear Shallow-Water,  
Dispersive PDEs.

### *Scientific computing.*

O.-O. programming,  
Generical programming,  
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 (*with honours*).

Master's Degree in Fundamental Mathematics.

*Highlights.* 1<sup>st</sup> in Theoretical Analysis, Numerical Analysis, Research Traineeship, a Posteriori Estimates courses.

*Rank.* Valedictorian.

### Undergraduate studies in Mathematics & Physics.

09/2017 - 05/2020

*Faculty of Sciences – Montpellier, France.*

Bachelor's Degree in Pure and Applied Mathematics (*with honours*).

Associate's Degree in Mathematics & Physics (*with honours*).

*Highlights.* 1<sup>st</sup> in Numerical Analysis of ODEs, Convex Optimization & Classical Mechanics courses.

*Rank.* Consistently ranked in the top 10 %.

## Work experiences

---

### Ph.D. candidate & teaching assistant.

10/2023 - Present

*IMAG & Engineering School Polytech Montpellier – Montpellier, France.*

### Research intern.

03 - 07/2023

*Institut Montpellierain 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

---

### Preparatory cycle mathematics (2<sup>nd</sup> year B.Sc.)

2023 - 2024

*Engineering School Polytech – Montpellier, France.*

*Description.* The preparatory cycle at Polytech Montpellier is tailored to prepare students for the pursuit of an engineering degree within any specialized field available in France. Mathematics courses are intentionally designed to be both comprehensive and profound, with a particular focus on students who aspire to explore theoretical domains such as mathematical engineering, physics, and mechanics.

*Topics.* Differential calculus, topology, bilinear algebra, probability.

### Supervised mathematical assignments (2<sup>nd</sup> year B.Sc.)

2023 - 2024

*Engineering School Polytech – Montpellier, France.*

*Description.* Supervised assignments is a specific system for students following the preparatory cycle in Polytech Montpellier, allowing them to assimilate the educational content provided by developing their autonomy and their capacity for self-assessment. Each week, students are placed in exam conditions with a subject to be covered in two hours. Teachers are there to guide them, help them overcome their difficulties and possibly become aware of their shortcomings.

## 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  $a, b \in \mathbb{N}^*$ , such that  $\gcd(a, b) = 1$ , the arithmetic progression  $\{an + b\}_{n \in \mathbb{N}}$  contains an infinity of prime numbers. Such a proof needs various theories, like complex analysis or group theory.

*Advisor.* Sylvain Brochard.

## 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

---

### “Fête de la Science” – Promoting scientific studies & professions.

10/2023

*Collaboration with Benjamin Charlier (IMAG) & Tristan Xabada (L2C-CBS) – Mende & Langogne, Lozère.*

We went to Peytavin & Saint-Pierre-Saint-Paul schools in order to promote mathematics professions, talk about our thesis subject and our student path with high schoolers (collaboration with IREM - Institut de Recherche sur l'Enseignement des Mathématiques).

## 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. It focuses on adapting teaching styles to various contexts, fostering interactivity, and developing collaborative projects. Additionally, it aims to innovate the learning model to align with 21st-century challenges, strengthening academic and socio-economic ties.

*Advisor.* Céline Avenel.

### Advanced programming for scientific computing.

10 - 12/2024

This intensive program covers several crucial and advanced aspects of C++, such as memory management, object-oriented programming concepts, and advanced data processing techniques for scientific research. Additionally, the course addresses the use of essential pre/post-processing tools in the context of complex scientific simulations. It also emphasizes the importance of modern collaborative work tools, such as version control systems, which have become indispensable in the context of collaborative and interdisciplinary research.

*Advisor.* Fabien Marche.

### Introduction to 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 university.* 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 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.

*Advisor.* Laurent Fauré.

## Computer skills

---

<b>Programming</b>	C/C++, Python, notions of Fortran.
<b>Mathematics softwares</b>	FreeFEM++, Matlab, Scilab, gnuplot, Maple, Mathematica.
<b>Markup languages</b>	HTML, CSS, PHP.
<b>Typesetting systems</b>	L <sup>A</sup> T <sub>E</sub> X, Beamer, Microsoft Office ( <i>Word &amp; PowerPoint</i> ).
<b>Operating systems</b>	Linux ( <i>Kali &amp; Debian</i> ), Windows, macOS.
<b>Creation softwares</b>	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 Bellicud.

### Finite-element resolution and FreeFEM++ simulation.

05 - 04/2022

*Numerical Analysis, introduction to 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*).

*Last update.* Monday 5<sup>th</sup> February, 2024.