

# SACHA CARDONNA

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## Current position

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### 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

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### *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

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### 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

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

10/2023 – Present

*IMAG & Faculty of Sciences – 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.*

## Internships

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### 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.

## Computer skills

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<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</i> & <i>PowerPoint</i> ).
<b>Operating systems</b>	Linux ( <i>Kali</i> & <i>Debian</i> ), Windows, macOS.
<b>Creation softwares</b>	Adobe Creative Cloud, Audacity, Final Cut Pro X.

## Projects

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### 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

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**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

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

*Last update.* Monday 17<sup>th</sup> July, 2023.