# Guillaume Lauga

*PhD*

*guillaume.lauga@univ-cotedazur.fr*
*https://laugaguillaume.github.io*

## Professional summary

I am a postdoctoral researcher at Université Côte d'Azur with a PhD in Applied Mathematics, specializing in numerical optimization, algorithm design, and scientific computing. My research involves developing mathematical algorithms, establishing theoretical convergence guarantees, and conducting reproducible numerical experiments. I also have experience in machine learning, LLM training, adversarial prompting, and developing scientific Python software. I am proficient in Python and scientific computing libraries, including PyTorch, NumPy, SciPy, and DeepInverse.

## PhD Thesis

title *Multilevel Proximal Gradient Algorithm for Image Restoration*

supervisors Paulo Gonçalves, Elisa Riccietti, Nelly Pustelnik

description The aim of this thesis was to study **multilevel strategies** in the context of **non-smooth optimization** in order to accelerate standard optimization methods for large-scale problems. Thesis defended on December 17, 2024 and awarded by ENS Lyon. (PDF)

## Professional Experience

July 2025–present **Postdoctoral Researcher**, *Université Côte d'Azur*, Nice, Project : study of inexact proximal operators and their interactions with plug-and-play methods. With Samuel Vaiter. Ongoing work : convergence of plug-and-play algorithms, and adversarial prompting of LLMs.

February 2025–May 2025 **Postdoctoral Researcher**, *ENS de Lyon*, Development and release of a modular Python library for implementing multilevel strategies in image restoration, ranging from variational approaches to plug-and-play methods : IMLFISTA.

2025–2026 **Teaching Assistant**, *Université Côte d'Azur, ENS de Lyon, École Centrale de Lyon, and Université Lyon 1*, Various courses in optimization and mathematics to undergraduate and Master students (More than 100 hours).

2024– **Reviewer**, for NeurIPS, and for the following journals : IEEE Transactions on Image Processing, Springer Journal of Optimization Theory and Applications, Springer Computational Optimization and Applications, and Springer Journal of Mathematical Imaging and Vision.

# Publications

2026 **Preprints**

- **G. Lauga**, C. Molinari, S. Vaiter, *Proximal basin hopping : global optimization with guarantees*, Under review at ICLR 2026 (PDF)

  In this work, we propose a global optimization algorithm for non-convex optimization. The algorithm, Proximal Basin Hopping, combines local minimization with proximal optimization. We establish convergence to the global minimizer, when it is unique, with high probability. We investigate the fitting of scaling laws on real data, with promising numerical results against state-of-the-art methods.
- **G. Lauga**, S. Vaiter, *Characterizations of inexact proximal operators.*, Under review at Open Journal of Mathematical Optimization, 2026 (PDF).

  In this work, we propose several characterizations of inexact proximal operators associated with potentially non-convex penalties. These characterizations allow us to identify the properties that an approximation of a proximal operator should satisfy so that, when used within a standard proximal minimization algorithm (proximal point, proximal gradient, or Douglas–Rachford), convergence to an approximate solution is preserved. This is achieved without assuming summability of the approximation errors, which is the standard assumption used to establish convergence in inexact optimization and, to our knowledge, by far the most common assumption in the literature.
- **G. Lauga**, *A block-coordinate descent framework for non-convex composite optimization. Application to sparse precision matrix estimation.*, Under review at Information and Inference : a Journal of the IMA, 2026 (PDF).

  In this work, we present a general framework for non-convex composite optimization using block-coordinate descent algorithms. The framework leads to three algorithms : a block-coordinate proximal-gradient method, potentially with a variable metric ; a block-coordinate proximal Newton method ; and a block-coordinate alternating minimization method. These three algorithms correspond to the three main classes of algorithms used to solve the non-convex sparse precision matrix estimation problem. We establish their convergence to a solution of the non-convex problem and computational speedups of up to $100\times$ compared with the standard reweighting approach.

2025 **Preprints**

- L. Briceño-Arias, P. Gonçalves, **G. Lauga**, N. Pustelnik, E. Riccietti, *A flexible block-coordinate forward-backward algorithm for non-smooth and non-convex optimization.*, Under review at Springer Applied Mathematics and Optimization, 2025 (PDF).

  In this work, we introduce a flexible framework for block-coordinate proximal-gradient algorithms that guarantees convergence to a critical point under a wide range of coordinate-update strategies, including cyclic updates, variable block sizes, and others. Algorithms fitting within this general framework can therefore address the optimization of non-smooth and non-convex functions. We establish the equivalence between a block-coordinate descent algorithm and a multilevel algorithm that has proven effective in image restoration. Finally, we present a non-convex image restoration example to validate the theoretical framework.

2021– **Accepted Publications**

▪ **G. Lauga**, M. Chaumette, E. Desainte-Maréville, É. Lasalle, A. Lebeurrier, *A multilevel approach to accelerate the training of Transformers*, GRETSI, August 2025 (PDF).
In this work, we propose a new multilevel method for accelerating the training of Transformers on text prediction tasks. The proposed method builds on the interpretation of residual neural networks as ordinary differential equations. Experimental comparisons demonstrate the potential of the method, with an approximately 40% reduction in the number of operations required to achieve equivalent performance.

▪ **G. Lauga**, E. Riccietti, L. Briceño-Arias, N. Pustelnik, P. Gonçalves, *Une équivalence entre algorithmes multiniveaux et algorithmes de descente par blocs*, GRETSI, August 2025, (PDF).
This paper presents in detail the equivalence between multilevel algorithms and block-coordinate algorithms mentioned above. The connection yields benefits in both directions, providing theoretical improvements for multilevel algorithms and practical improvements for block-coordinate algorithms.

▪ **G. Lauga**, A. Repetti, E. Riccietti, N. Pustelnik, P. Gonçalves, Y. Wiaux, *A multilevel framework for accelerating uSARA in radio-interferometric imaging*, EUSIPCO, August 2024 (PDF).
In this work, we demonstrate the flexibility of the IML FISTA algorithm (see below) by constructing a hierarchy of approximations to the radio-interferometric image reconstruction problem in the observation space, rather than in the image space as is usually done. Significant computational-time improvements are observed in experiments using simulated data.

▪ **G. Lauga**, E. Riccietti, N. Pustelnik, P. Gonçalves, *IML FISTA : A Multilevel Framework for Inexact and Inertial Forward-Backward. Application to Image Restoration, SIAM Journal on Imaging Sciences*, 2024 (PDF).
In this work, we propose a general multilevel framework for inexact non-smooth convex optimization. We provide the first convergence proof to a solution for an inexact multilevel algorithm, allowing IML FISTA (Inexact Multilevel Fast Shrinkage Thresholding Algorithm) to match at least the theoretical guarantees of state-of-the-art algorithms. The proposed framework can handle penalties whose proximal operators cannot be computed in closed form and therefore require an approximation at each iteration. Although this procedure is computationally expensive, it enables the use of penalties that can yield higher-quality image reconstructions. By efficiently handling such penalties, IML FISTA substantially accelerates the solution of image restoration problems. We demonstrate its performance on a wide range of image restoration problems involving different types of degradation and image content.

▪ **G. Lauga**, E. Riccietti, N. Pustelnik, P. Gonçalves, *Méthodes multi-niveaux pour la restauration d'images hyperspectrales*, GRETSI, August 2023 (PDF).
In this work, we apply the multilevel methodology of IML FISTA to hyperspectral image reconstruction and propose two approaches for reducing the problem dimension. Both approaches are highly competitive with standard methods such as FISTA.

▪ A. Gonon, L. Zheng, C. Lalanne, Q.-T. Le, **G. Lauga**, C. Pouliquen, *Can sparsity improve the privacy of neural networks ?*, GRETSI 2023 (PDF).
In this work, we investigate the impact of sparsity on the privacy of neural networks, i.e., their ability not to reveal whether particular samples belong to their training set. We highlight a correlation between sparsity and privacy.

▪ **G. Lauga**, E. Riccietti, N. Pustelnik, P. Gonçalves, *Multilevel FISTA for image restoration*, ICASSP, June 2023 (PDF).
In this work, we extend the results of our previous multilevel algorithm by incorporating a standard acceleration technique, namely momentum. The resulting algorithm therefore enjoys optimal convergence guarantees. We present an application to an image restoration problem in which our multilevel algorithm outperforms FISTA in practice.

▪ **G. Lauga**, E. Riccietti, N. Pustelnik, P. Gonçalves, *Méthodes proximales multi-niveaux pour la restauration d'images*, GRETSI, September 2022 (PDF).
In this work, we provide the first proof of convergence of a multilevel proximal-gradient algorithm to a solution of a convex minimization problem. An application to an image restoration problem is presented.

**Oral Presentations**

- Proximal Basin Hopping, Workshop STOP Lyon 2026
- Characterizations of inexact proximal operators, EUROPT 2026
- Co-organizer of the mini-symposium "Challenges and Recent Advances in Multilevel Optimization" with Elisa Riccietti (12 oral presentations at SIAM OPT 2026)
- Characterizations of inexact proximal operators, SIAM OPT 2026
- Characterizations of inexact proximal operators, SMAI MODE 2026
- Block-coordinate descent : a new flexible convergence framework and application to sparse precision matrix estimation, Probability and Statistics Seminar, Nice, November 25, 2025
- Block-coordinate descent : equivalence with multilevel methods and application to sparse precision matrix estimation, Inria Saint-Étienne, November 18, 2025
- Multilevel Proximal Methods for Radio-interferometric imaging, EURO, July 2024
- Multilevel Proximal Methods for Image Restoration, Seminar, Johannes Kepler University, Linz, June 2024
- Multilevel Proximal Methods for Radio-interferometric imaging, SIAM LA, May 2024
- Multilevel Proximal Methods for Image Restoration, Seminar, INSA Rouen, April 23, 2024
- _____, SMAI MODE, March 26–29, 2024
- _____, Workshop on Optimization, Berlin, June 14–16, 2023
- _____, Optimization and Control in Burgundy, May 9–11, 2023
- _____, Seminar, Institut de Mathématiques de Bordeaux, May 4, 2023
- _____, SIAM CSE, March 2023

## Education

2017–2021 **Master 2 : general engineering degree, with a specialization in Mathematics**, *École Centrale de Lyon*, Lyon

2020–2021 **Master 2 in Applied Mathematics and Statistics – Environment and Climate Track**, *École Centrale de Lyon / ENS de Lyon / Université Lyon 1*, Lyon

2018–2019 **Bachelor's Degree in General Mathematics**, *Université Lyon 1*, Lyon

2015–2017 **Preparatory Classes for the French Grandes Écoles – Physics and Technology (PT)**, *Lycée Jules Ferry*, Versailles