Loïc Gouarin

Research engineer in scientific computing

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Professional experience

CNRS — *CMAP - École polytechnique*

Research engineer — *Since 2018*

CNRS — *LMO - Université Paris-Saclay*

Research engineer — *2010 - 2018*

CNRS — *LAGA - Université Paris 13*

Research engineer — *2005 - 2010*

ONERA (French Aerospace Lab) — *Châtillon*

PhD — *2001 - 2005*

- Development of a code for modelling three-dimensional reactive turbulent flows in the High Performance Computing department, as part of a PhD in applied mathematics supervised by L. Halpern and J. Ryan

Skills

Mathematics	classical numerical methods, lattice Boltzmann schemes, mesh adaptation, domain decomposition
Programming languages	C++, Python, Julia, JavaScript, C, Fortran, LaTeX
DevOps	Kubernetes, Docker, Terraform, Ansible
Software engineering	version control, unit testing (pytest, GoogleTest), packaging (PyPI, conda), formatting (black, clang-format), continuous integration
Project management	writing scientific and technical proposals, running meetings, assigning and tracking tasks, setting objectives, hiring and supervision
Event organisation	training courses and scientific or technical days, choice of topics, funding applications, negotiation with suppliers, registration management, financial and scientific reports
Languages	French, English

Education

Université d'Aix-Marseille II — *Marseille*

Master's degree (DEA) in fluid mechanics — *2000 - 2001*

ISITV (Toulon engineering school) — *La Garde*

Engineering degree — *1998 - 2001*

- major in modelling and scientific computing

Université de Cergy-Pontoise — *Cergy-Pontoise*

Bachelor's degree in pure mathematics — *1997 - 1998*

Open-source projects

Samurai

github.com/hpc-maths/samurai

Project lead — *Since 2015*

- Samurai is a new generation of data structures for mesh adaptation methods.
- The library is written in C++ and relies heavily on xtensor.
- It lets users benefit from the latest advances in mesh adaptation transparently in their numerical simulations.
- Samurai is used and developed by PhD students and postdocs of the laboratory.
- Several external collaborations are emerging (ONERA, École centrale, …).

pylbm

github.com/pylbm/pylbm

Project lead — *Since 2015*

- pylbm is a Python package for running numerical simulations with lattice Boltzmann methods easily.
- It is aimed at mathematicians, physicists and computer scientists.
- The strength of pylbm is to generate numerical code from symbolic mathematics according to what the user asks for. Several back ends are available: Cython, NumPy or Loo.py. pylbm supports MPI through mpi4py.
- It is used in a project funded by ESA (the European Space Agency) in partnership with CENAERO, the Von Karman Institute and the Orsay mathematics laboratory.
- We see 300 downloads per month.

SCoPI

github.com/hpc-maths/scopi

Project lead — *Since 2019*

SCoPI, written in C++, is designed for the simulation of interacting particle collections. It simulates 2D and 3D particles (with convex regular shapes) interacting with their surroundings (obstacles of various kinds, moving or not, gravity, optional coupling with a fluid solver) and with other particles (inter-particle forces, contacts). The contact model can be dry (inelastic, with or without friction) or viscous (modelling lubrication forces in a viscous fluid). The algorithms are implicit and reduce, at each time step, to solving a constrained convex problem.

xeus-cling

github.com/jupyter-xeus/xeus-cling

Lead developer — *Since 2017*

- The project was started to make learning C++ easier for students and in continuing education courses.
- It runs in Jupyter notebooks, now widely used for teaching and reproducible research.
- It was downloaded more than 100,000 times in two and a half years.

CAFES

github.com/gouarin/cafes

Project lead — *Since 2015*

CAFES (CArtesian Finite Element Solvers) is written in C/C++ and parallelised with MPI. It relies heavily on PETSc for finite element matrices and solvers. Its goal is to solve problems that need a solver on a Cartesian grid, such as fluid - rigid particle interactions, the influence of cilia on flows (for example bronchial cilia) or micro-swimmers moving in a viscous fluid. In each case, a constrained problem is written by solving several Stokes problems with a right-hand side that accounts for the particles, the cilia, … The software is used in the ANR project RheoSuNN.

GenEO

github.com/gouarin/GenEO

Project lead — *Since 2018*

- GenEO implements a new generation of domain decomposition solvers that remain efficient when the matrix of the linear system varies strongly.
- The library is written in Python.
- Several papers presenting the method and its use cases are in preparation.

xtensor-sparse

github.com/xtensor-stack/xtensor-sparse

Project co-lead — *Since 2020*

- The library is written in C++ and describes N-dimensional sparse tensors easily.
- It is built on xtensor.
- Development is carried out in collaboration with the company QuantStack.

Other responsibilities

Since 2022	**Co-head**, HPC@Maths team at CMAP	*École polytechnique*
Since 2020	**Head**, working group for a modern teaching platform	*École polytechnique*
2013 - 2019	**Director**, GdR Calcul (CNRS research network)	*National*
2010 - 2018	**Co-head**, MITI network: Calcul	*National*
Since 2019	**Member**, gender parity and professional equality committee	*CMAP*
2020 and 2021	**Member**, CNRS internal promotion panels	*National*
Since 2019	**Member**, laboratory council	*CMAP*
Since 2017	**In-house trainer**, CNRS	*National*
2016	**Head**, working group on the REFERENS II job profiles for scientific computing requested by the CNRS OMES	*National*
2013 - 2023	**Member**, steering committee of the LoOPS network	*Paris-Saclay*

Teaching

Degree programmes

Since 2022	**Engineering school**, Algorithms and software design principles for applied mathematics in modern C++	*École polytechnique*
2010 - 2018	**3rd-year mathematics degree**, Algorithms and programming in C	*Université Paris-Saclay*
2001 - 2007	**Engineering school**, Supervised projects in C and Matlab	*Université Paris 13*

Continuing education

2023 - 2024	**Workshop**, Development framework and automation for open source	*CNRS*
2017 - 2019, 2024	**In-house trainer**, Development process of a Python application	*CNRS*
2017	**Workshop**, Advanced Python for scientific computing	*Paris*
2013	**Equip@meso**, Introductory PETSc workshop	*Saclay*
2013	**ANF**, Advanced Python in scientific computing	*Fréjus*
2011	**Thematic school**, Domain decomposition methods: from theory to practice	*Fréjus*
2010	**ANGD**, Python in scientific computing	*Autrans*

Publications

samurai/ponio: two complementary software libraries for the efficient implementation of adaptive space/time numerical schemes — *2026*

Sébastien Dubois, **Loïc Gouarin**, Alexandre Hoffmann, Josselin Massot, Marc Massot, Pierre Matalon, Laurent Séries

Report, HAL

High Performance Parallel Solvers for the time-harmonic Maxwell Equations — *2025*

Élise Fressart, Sébastien Dubois, **Loïc Gouarin**, Marc Massot, Michel Nowak, Nicole Spillane

Preprint, arXiv

A new modeling approach of Myxococcus xanthus bacteria using polarity-based reversals — *2024*

Hélène Bloch, Vincent Calvez, Benoît Gaudeul, **Loïc Gouarin**, Aline Lefebvre-Lepot, Tâm Mignot, Michèle Romanos, Jean-Baptiste Saulnier

ESAIM Proceedings and Surveys

Fully algebraic domain decomposition preconditioners with adaptive spectral bounds — *2024*

Loïc Gouarin, Nicole Spillane

ETNA - Electronic Transactions on Numerical Analysis

Does the multiresolution lattice Boltzmann method allow to deal with waves passing through mesh jumps? — *2022*

Thomas Bellotti, **Loïc Gouarin**, Benjamin Graille, Marc Massot

Comptes Rendus Mathématique

High accuracy analysis of adaptive multiresolution-based lattice Boltzmann schemes via the equivalent equations *2022*

Thomas Bellotti, **Loïc Gouarin**, Benjamin Graille, Marc Massot

SMAI Journal of Computational Mathematics

Multidimensional fully adaptive lattice Boltzmann methods with error control based on multiresolution analysis *2022*

Thomas Bellotti, **Loïc Gouarin**, Benjamin Graille, Marc Massot

Journal of Computational Physics

Multiresolution-Based Mesh Adaptation and Error Control for Lattice Boltzmann Methods with Applications to Hyperbolic Conservation Laws *2022*

Thomas Bellotti, **Loïc Gouarin**, Benjamin Graille, Marc Massot

SIAM Journal on Scientific Computing

Optimized Schwarz waveform relaxation for advection reaction diffusion equations in two dimensions *2015*

Daniel Bennequin, Martin J. Gander, **Loïc Gouarin**, Laurence Halpern

Numerische Mathematik

A smooth extension method *2013*

Benoît Fabrèges, **Loïc Gouarin**, Bertrand Maury

Comptes Rendus Mathématique

Pourquoi une structuration des mésos-centres en France ? *2013*

Loïc Gouarin, Romaric David, Laurent Séries, O. Politano, Pierre Gay

Conference paper, HAL

Linear lattice Boltzmann schemes for acoustic: Parameter choices and isotropy properties *2012*

Adeline Augier, François Dubois, **Loïc Gouarin**, Benjamin Graille

Computers & Mathematics with Applications

3D Direct Simulation of a Nonpremixed Hydrogen Flame with Detailed Models *2010*

Gordon Fru, Dominique Thévenin, C. Zistl, Gábor Janiga, **L. Gouarin**, A. Laverdant

Chapter, ERCOFTAC series

Optimized Schwarz Waveform Relaxation Methods: A Large Scale Numerical Study *2010*

Martin J. Gander, **Loïc Gouarin**, Laurence Halpern

Chapter, Lecture notes in computational science and engineering

Interaction of a Gaussian acoustic wave with a turbulent non-premixed flame *2007*

A. Laverdant, **L. Gouarin**, Dominique Thévenin

Combustion Theory and Modelling

Interests

Reading, hiking, gardening and DIY