Nathanaëlle Courant

Ph.D. Student in Computer Science

Education

2019–2022 (planned) **Ph.D.**, *Team Cambium, Inria Paris*.
Ph.D. with Xavier Leroy: "Towards an efficient, formally-verified proof checker for Coq".

2018–2019 **Research internship**, *Team Celtique, Inria Rennes*.
Research internship with Thomas Jensen and Alan Schmitt:
"A Rule-based Format for Operational Semantics: formalisation and applications".

2016–2018 **Computer science research master's degree (MPRI)**, *École Normale Supérieure*, Paris.
M1 research internship with Natarajan Shankar: "Verified code generation for the PVS2C code generator"; M2 research internship with Xavier Leroy: "Verified code generation for the polyhedral model". Admitted with average mark 19.46/20, ranked 1st.

2015–2016 **Bachelor's degree**, *École Normale Supérieure*, Paris.
3rd year of Bachelor's degree in both computer science and mathematics. Research internship with Caterina Urban: "Improved widening operators for proving termination by abstract interpretation".

2013–2015 **"Classes préparatoires"**, *Lycée du Parc*, Lyon.

Achievements

2020 **ICFP Programming Contest**.
Team "All your galaxy combinator are belong to us"; ranked 2nd in the lightning round and 7th in the full contest.

2015–2017 **ACM-ICPC SWERC (Southwestern Europe Regional Contest)**.
Team "ENS Ulm 1": ranked 3rd in 2015, 1st then 34th at the world finals in 2016, 1st then 56th at the finals in 2017.

2016 **Google Code Jam**.
Selected for the final round; ranked 18th.

2016 **Google Hash Code**.
Team "OCaml4Ever"; ranked 9th.

2015 **École Normale Supérieure (Paris) national competitive examination**.
Ranked 2nd; also ranked 1st on the entrance examinations of École Normale Supérieure of Lyon and Rennes, 6th at École Normale Supérieure of Cachan, and 7th at École Polytechnique.

2014–2016 **Prologin**.
French programming contest. Ranked 1st in 2016, 10th in 2015 and 4th in 2014.

2013 **International Mathematical Olympiad**.
Member of the French team. Was awarded a silver medal.

2013 **Concours général des lycées (National competition)**.
1st prize in physics and in engineering sciences, 2nd prize in mathematics.

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Publications

2022 **‹Programming› 2022**, Nathanaëlle Courant, Julien Lepiller, Gabriel Scherer.
Debootstrapping without Archeology: Stacked Implementations in Camlboot

2021 **POPL 2021**, Nathanaëlle Courant, Xavier Leroy.
Verified Code Generation for the Polyhedral Model

2020 **CPP 2020**, Nathanaëlle Courant, Antoine Séré, Natarajan Shankar.
The Correctness of a Code Generator for a Functional Language

2017 **TACAS 2017**, Nathanaëlle Courant, Caterina Urban.
Precise Widening Operators for Proving Termination by Abstract Interpretation

Teaching

2021–2022 **TA for the compilation course at ENS Paris**.

2019–2021 **Coaching teams for SWERC at École Polytechnique**.
Course for coaching the teams of École Polytechnique for the SWERC.

2019–2020 **TA for the "Mechanisms of OOP" course at École Polytechnique**.

2018–2019 **Mathematics oral examinations in MP***.
One hour oral examinations each week, in MP* (second-year students) at the lycée Chateaubriand (Rennes). A few hours of preparation to the oral examinations of mathematics and computer science at the end of the year.

2014–2018 **Teaching at the *club de mathématiques discrètes* in Lyon**.
Club for high school students for the preparation of the International Mathematical Olympiad, about one day each year.

2015–2016 **Tutoring sessions in mathematics for a MPSI student**.
Tutoring sessions for a MPSI student. About two hours per week for six months.

Skills

Languages: French (native language), English (fluent), German (intermediate).

Programming languages: *In order of decreasing proficiency*: OCaml, Coq, Python, Lua, C/C++, Scheme, and some experience with other languages, including: x86-64 and ARM assembly, Forth, Zig.

Programming experience

- An evaluator for the lambda-calculus with strong call-by-need reduction, proved correct in Coq. A version of it was merged into the OCaml compiler in 2022 as part of the "shape" analysis.
- An interpreter for OCaml written in a small subset of OCaml, and a compiler of this subset of OCaml to OCaml bytecode written in Scheme. Together, they allow *debootstrapping* the OCaml compiler.
- A verified code generator for the polyhedral model, that generates an AST for scanning many polyhedra, written and proved in Coq.
- A compiler from a small purely functional language to C, including algebraic datatypes, algebraic effects with multi-shot continutations, a garbage collector, and a static type system that checks the effects.
- A verified code generator, from a small functional language to an imperative language, including

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proof of correctness of reference-counting and destructive updates, written and proved in PVS.
- Code review for the initial smart contract of the Tezos blockchain in 2018.
- At the time of writing, solved the first 707 project Euler problems.
- A compiler from a subset of Scala to x86-64 assembly, written in OCaml.
- A netlist-to-C compiler and a CPU written in this netlist language. The compiler was written in OCaml, the CPU generated with Python.
- A minimalistic OS to boot a Raspberry Pi on, written in C, C++ and ARM assembly.
- Implementing a fully Forth-83-compliant system, written in Python and Forth.
- Proving the theorem of quadratic reciprocity using Coq.
- Core developper of Minetest, an open-source video game written in C++ and Lua.

Theoretical knowledge

Computer science	Compilation, semantics, typing, λ-calculus, linear logic, abstract interpretation, algorithms, computability, complexity, category theory, machine learning, convex optimization, and cryptography.
Mathematics	Measure theory, basic algebra, topology, complex analysis, probabilities.

Hobbies

Programming, climbing, building LEGO, reading science-fiction, playing some video games (Factorio, Minetest, ...).

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