

Dr. Anthony Bordg

Curriculum Vitae

I am a mathematician and computer scientist at the University of Cambridge (UK), with a passion for the foundations of physics (quantum mechanics ...). In particular, I am an expert in logic and the foundations of mathematics (Univalent Foundations/Homotopy Type Theory) and in the field of formal methods for the formalisation of mathematics (Institute for Advanced Study, 2013; Fulbright, 2014; Heidelberg Laureate Forum invited young researcher, 2017).

Appointments

- 2018–present **Research Associate**, Computer Laboratory, University of Cambridge (UK), 5-year position as Research Associate on the ALEXANDRIA project (<https://www.cl.cam.ac.uk/~lp15/Grants/Alexandria/>), €2,5M ERC-funded project led by Prof. Lawrence C. Paulson, a Fellow of the Royal Society.
- Aug. 2018–June 2019 **Research Fellow**, Centre for Advanced Study at the Norwegian Academy of Science and Letters (field: Mathematics), project *Homotopy Type Theory and Univalent Foundations* (<https://cas.oslo.no/research-groups/homotopy-type-theory-and-univalent-foundations-article2083-827.html>).
- 2015–2017 **Postdoctoral Fellow**, Eduard Čech Institute for Algebra, Geometry and Physics, Mathematical Institute, Charles University (Prague, Czech Republic).
- 2012–2015 **Research Assistant**, CNRS (UMR 7351) & Université Nice-Sophia Antipolis.
- 2010–2012 **Teacher**, private school ADMISUP, Paris (8th arrondissement).
head of the math option for “Préparation Sciences Po Paris” and in charge of coaching students for the TAGE Mage (French test for business and management studies)

Qualifications

- 2021 **Qualification aux fonctions de Maître de Conférences**, section 25 Mathématiques, credential ID 21225291921, Conseil National des Universités (CNU).
- 2016 **I have obtained my French Qualification aux fonctions de Maître de Conférences**, section 25 Mathématiques, credential ID 16225291921, Conseil National des Universités (CNU).

Education

- 2012–2015 **PhD in Mathematics**, awarded with Distinction, fully-funded by a 3-year French governmental grant, advisor Emeritus Prof. André Hirschowitz, Université Nice Sophia Antipolis, Ecole Doctorale Sciences Fondamentales et Appliquées, Laboratoire J.A. Dieudonné, team Algèbre, Topologie et Géométrie, doctoral thesis title: *On Lifting Univalence to the Equivariant Setting*.
In my thesis, I worked on a “model invariance principle” conjectured by Prof. Michael Shulman. I was able to disprove Shulman’s conjecture and my work was published in Applied Categorical Structures, a top-tier mathematics journal.
keywords: Univalent Foundations, Homotopy Type Theory, Univalence Axiom, Quillen model category, type-theoretic fibration category, Model Invariance Problem, universe, groupoid.

- 2012–2013 **Invited graduate student**, Institute for Advanced Study, School of Mathematics, Princeton (USA), I was a participant in the Special Year on the Univalent Foundations of Mathematics organized by Steve Awodey, Thierry Coquand, and Vladimir Voevodsky. During the special year I raised an issue with the experimental implementation of higher inductive types in the COQ language. This issue was later fixed by Yves Bertot, see <https://groups.google.com/g/univalent-foundations/c/e2NyQ3QuvXs..>
- 2010–2012 **Master's degree (Master recherche) in Mathematics**, Magna Cum Laude (I was in the top 5 students), Université Paris Diderot, Paris.
- 2006–2010 **Licentiate's degree in Mathematics**, Université Pierre et Marie Curie, Paris.
- 2005–2006 **Master's degree (Maîtrise) & Magister in Philosophy**, Université Paris-Sorbonne & Ecole Normale Supérieure, Paris.
Master LOPHISS (Logic, Philosophy and Sociology of Science)
- 2002–2005 **Licentiate's degree in Philosophy**, Université Paris-Sorbonne, Paris.

Miscellany

- 2012 **intern**, *University Nice Sophia Antipolis*, Nice, France.
3-month internship supported by a grant at the Laboratoire J.A. Dieudonné under the supervision of Prof. André Hirschowitz
- 2008–2010 **teacher**, *Academia*, Paris (16e arrondissement).
private and group classes
- 2000–2001 **blue-collar worker**.
Various summer jobs

Awards and Distinctions

- 2019 **Royal Academy of Engineering (RAEng) internal selection**, winner of the internal selection at the Department of Computer Science and Technology of the University of Cambridge for a RAEng Fellowship (selection conducted by the Head of Department, Prof. Ann Copestake).
- Sept. 2017 **Heidelberg Laureate Forum**, *invited young researcher*.
- 2015 **Laureate of an Eole grant**, (French-Dutch award of excellence, 500€).
- 2014 **Laureate of a Fulbright grant**, (\$10 000) During my PhD, as a Fulbright Fellow I was invited for 3 months to Carnegie Mellon University (CMU) in Prof. Steve Awodey's group and for 3 additional months to the Department of Mathematics of the University of San Diego (USD) to present my work.
- 2013 **Notable Computing Books and Articles of 2013**, the collective book *Homotopy Type Theory: Univalent Foundations of Mathematics* made the list of the "Notable Computing Books and Articles of 2013" of *Computing Reviews*.

Preprints & Publications

Mathematics research

- 2019 **On a Model Invariance Problem in Homotopy Type Theory**, Applied Categorical Structures. <https://doi.org/10.1007/s10485-019-09558-w>, arXiv:1712.03409.
- 2016 **From Functors between Categories to Homomorphisms of C-systems**, arXiv:1710.02028.
- 2015 **On the Inadequacy of the Projective Structure with Respect to the Univalence Axiom**, arXiv:1712.02652.
submitted

- 2013 **Homotopy Type Theory: Univalent Foundations of Mathematics**, The Univalent Foundations Program, Institute for Advanced Study, Princeton.
This book is the standard reference on the Univalent Foundations of Mathematics and it is available online <http://homotopytypetheory.org/book/>.

Computer science research

- 2021 **Simple Type Theory is not too Simple: Grothendieck's Schemes without Dependent Types**, arXiv:2104.09366.
- 2020 **Certified Quantum Computation in Isabelle/HOL**.
Journal of Automated Reasoning 65(5) 691-709 <https://doi.org/10.1007/s10817-020-09584-7>

Physics research

- 2019 **Comment on Quantum Games and Quantum Strategies**, *this work uncovered an error in the pioneering, highly cited, article of quantum game theory published in Physical Review Letters, a high-profile journal, and it led to the publication of an erratum in the same journal*, arXiv:1911.09354.

Computer code

- 2021 **Grothendieck's Schemes in Algebraic Geometry**, Archive of Formal Proofs.
https://www.isa-afp.org/entries/Grothendieck_Schemes.html
- 2020 **Isabelle Marries Dirac: a Library for Quantum Computation and Quantum Information**, Archive of Formal Proofs.
https://www.isa-afp.org/entries/Isabelle_Marries_Dirac.html
- 2018 **The Localization of a Commutative Ring**, Archive of Formal Proofs.
https://www.isa-afp.org/entries/Localization_Ring.html
- 2018 **Projective Geometry**, Archive of Formal Proofs, this work made Freek Wiedijk's epoch-making online list "Formalizing 100 Theorems" (*cf.* item 87 for Desargues's Theorem and the additional list for Hessenberg's theorem, <https://www.cs.ru.nl/~freek/100/>).
https://www.isa-afp.org/entries/Projective_Geometry.html

Expository writing and Scientific Outreach

- 2021 **What is a Scheme in Algebraic Geometry?**, https://drive.google.com/file/d/19hses0Z170hmzYxcV_OgIN0gIg2SBD1q/view?usp=sharing.
- 2021 **A Replication Crisis in Mathematics?**, Math Intelligencer <https://doi.org/10.1007/s00283-020-10037-7>.
At some point this article was in the top 25% of all research outputs scored by Altmetric and it had one of the highest attention score compared to the outputs of the same age (88th percentile) and of the same age and source (99th percentile).
- 2019 **Univalent Foundations and the UniMath library**, in *Reflections on the Foundations of Mathematics: Set Theory, Univalent Foundations and General Thoughts*, Synthese Library, vol 407, Springer, arXiv:1710.02723.

Textbooks

- 2016 **L'épreuve de mathématiques à Sciences Po**, Ed. Ellipses, collection Optimum.
maths textbook, in French

Translations

- 2010 **L'Ecole de New Haven de droit international**, Ed. Pedone, collection Doctrine(s), Paris, 2010, translation in French, led by Dr. Julien Cantegreil, of ten papers of Prof. Michael Reisman (Myres S.McDougal Professor of International Law at Yale Law School).

Computer Code

- 2020 **Geometry in Lean**, differential geometry in the Lean theorem prover, joint work with Nicolò Cavalleri.
https://github.com/AnthonyBordg/Geometry_in_Lean
- 2019 **Lie**, Lie groups in the Isabelle proof assistant, pilot study with Michael R. Douglas.
<https://github.com/AnthonyBordg/Lie>
- 2017 **UniLab**, mathematical formalizations based on the Univalent Foundations of mathematics. I formalized (with the Coq proof assistant) comma categories, the univalent category of modules over a ring, monoidal categories, algebras over a commutative ring, types and groups with operators. Part of my work was integrated in Vladimir Voevodsky's UniMath library who cited my work during his talk at the Isaac Newton Institute for Mathematical Sciences in Cambridge as an example of a reformulation of a piece of mathematics using the univalent point of view (see p. 15 of Voevodsky's slides <https://www.newton.ac.uk/files/seminar/20170710113012301-1356379.pdf>).
<https://github.com/AnthonyBordg/UniLab>

International Guests

- 14-23 Dec 2017 Guest: Prof. Hirokazu Nishimura (University of Tsukuba)
- 17-23 Dec 2017 Guest: Dr. Felix Wellen (Carnegie Mellon University)

Supervisions

- April-? 2021 supervision of Nicolò Cavalleri's Master 2 thesis (École Normale Supérieure, Paris)
- April-? 2021 supervision of Zibo Yang (Master I MPRI) from École Polytechnique, Paris
- June-August 2020 I supervised the internships of Nicolò Cavalleri, a Part III student of the Mathematical Tripos (St. Edmund's College, University of Cambridge), and Jiaqi Qiao, a 4th year student in mathematical physics at the University of Edinburgh. We worked on the formalization of mathematical physics in the Lean theorem prover. Nicolò and I were awarded a grant from the Cambridge Mathematics Placements Programme of the Department of Pure Mathematics and Mathematical Statistics, while Jiaqi was supported by the University of Edinburgh.
- 2019-2020 Supervising Xiao Ma's Part II Dissertation on deep learning (Gonville and Caius College, University of Cambridge).
- June-August 2019 I supervised the internship of Hanna Lachnitt, the second recipient of the Helmut Veith Prize awarded annually to an outstanding female Master's Student in computer science at TU Wien (Austria). Our project was awarded an Erasmus+ grant.
- June-August 2019 I supervised the internship of Yijun He, a 2nd-year student from the Mathematical Tripos (St. John's College, University of Cambridge). Yijun and I were awarded a grant from the Cambridge Mathematics Placements Programme.
- April-August 2018 I co-supervised (with Prof. Larry Paulson) the internship of two students (Master I), Martin Baillon and Paulo Emilio de Vilhena, from École Polytechnique (Paris, France). One can read their work on GitHub <https://github.com/DeVilhena-Paulo/GaloisCVC4>.
- April 2018 I was invited to take part in the MPhil project focus group of Andreas Theocharous (MPhil student, University of Cambridge) who works on Speedith, a diagrammatic reasoner for spider diagrams.

Academic Responsibilities

- July 2021 programme committee member of the *Fifth Workshop on Formal Mathematics for Mathematicians* associated with the *14th Conference on Intelligent Computer Mathematics*
- 2021–present member of UKRI Early Career Researcher Forum that gives researchers a voice in UKRI's strategy, policy development and decision making. UK Research and Innovation (UKRI) is the public body that directs research and innovation funding in the UK.
- 2019 Referee for *Internal Junior Fellowships*, Freiburg Institute for Advanced Studies.
- 2019–present Administrator of the Zulip chat that I initiated for the Isabelle community (Isabelle is a proof assistant) <https://isabelle.zulipchat.com/>.
- Mar. 2019 I organized and led interviews of part III students of the Mathematical Tripos for the Cambridge Mathematics Placements (CMP) programme.
- 2017–present Reviewer for scientific journals
- 2014–2015 Elective representative of doctoral students for the Council of my Doctoral School (ED SFA, Université Nice Sophia Antipolis).

Professional Development

- Jan. 2020 Career Development Fellowships sessions, University of Cambridge
- Oct. 2019 Dissertation Marking Workshop, University of Cambridge

Computer Skills

Mathematica, Isabelle, COQ, Lean, \LaTeX , git, emacs, Linux, OCAML, SHEME, Scilab, VBA.

Online StackExchange Profiles

- Math <http://math.stackexchange.com/users/346996/anthony-bordg?tab=profile>
- Physics <https://physics.stackexchange.com/users/144508/anthony-bordg>
- Politics <https://politics.stackexchange.com/users/22961/anthony-bordg>

Community Services

- 2020–present mentor of a senior high school student with the French organization *Chemins d'avenirs*
- 2020–present blogger at francedoctorat.fr and okaydoc.fr for the valorisation of doctorate in France
- 2020–present Due to the COVID-19 pandemic the 2020-21 academic year at the University of Cambridge will take place online. To help students cope with this unprecedented situation, I launched a specialized online chat of which I am the administrator, the *Schrödinger's Chat* (<https://cam-mathphys.zulipchat.com>), for students and alumni of the Mathematical and Natural Sciences Triposes. In particular, we organize online reading groups for various courses.

Social media

- Linkedin <https://www.linkedin.com/in/anthony-bordg-560454156/>
- Blogger An old blog with few posts (mainly about cinema and education) in French <http://anthony-bordg.blogspot.com/>

Languages

- French mothertongue
- English read, written and spoken

Memberships (past and present)

- 2018-present Member of the Cambridge University Physics Society
- 2015-present Member of the French Fulbright alumni association
- 2014 Member of the Association for Symbolic Logic

Civil status

- Free union
- Father-of-one

Interests

- hiking
- Physics
- Logic
- tennis
- Artificial Intelligence
- History of mathematics