

# Nicolas Boullé

## Research interests

Numerical analysis, machine learning, operator learning

## Employment

- 2024-date **Assistant Professor in Applied Mathematics**, Imperial College London, UK.  
Department of Mathematics.
- 2022-2024 **Research Fellow**, University of Cambridge, UK.  
Isaac Newton Institute and Department of Applied Maths and Theoretical Physics.

## Education

- 2018-2022 **DPhil in Numerical Analysis**, University of Oxford, UK.  
Supervised by Prof. Patrick Farrell and Prof. Alex Townsend.
- 2017-2018 **Visiting Research Student**, Cornell University, USA.  
Supervised by Prof. Alex Townsend.
- 2015-2017 **BSc and 1st year of MSc in Mathematics**, ENS Rennes, France.
- 2013-2015 **University foundation course in Mathematics**, Lycée Saint-Louis, France.

## Research prizes

- 2024 **SIAM Activity Group on Linear Algebra Best Paper Prize**
- 2023 **IMA Lighthill-Thwaites Prize**, 2nd place.
- 2022 **STEM for Britain**, finalist.
- 2021 **IMA Leslie Fox Prize for Numerical Analysis**, 2nd prize.
- 2021 **G-Research PhD Prize**, 2nd place (£5000).

## Research grants and fellowships

- 2023-2028 **Scientific Artificial Intelligence (SciAI) Center**, Office of Naval Research, \$11.3m,  
Imperial PI, personal support: \$485k.
- 2022-2023 **INI-Simons Postdoctoral Research Fellowship**, Simons Foundation.

## Research supervision

PhD students:

- Gustav Conradie (Cambridge, with Matt Colbrook), 2024-present.
- Christina Runkel (Cambridge, with Carola Schönlieb), 2021-present.

Undergraduate and MSc students: Markus Dablander (2020), Franklin Deng, Jack Krew, Henry Smith (2021), Emily Zhang, Qile Jiang (2023), Gustav Conradie (2024), Yudi Cai, Penelope Forcioli, Emmet Haddad, Moritz Hauschulz, Ade Olugboji, Lars Slettengren, Emre Ulusoy, Advait Velavan, Yaxuan Wang, Oussama Zekri, Zihan Zhou (2025).

## Teaching

- 2025-date **Lecturer for Mathematical Foundations of Machine Learning**, Imperial College London.
- 2025 **Lecturer for Finite Element**, AIMS Rwanda.
- 2019-2021 **TA/Tutor for Approximation of functions**, University of Oxford.
- 2019 **TA for Practical Numerical Analysis**, University of Oxford.

## Professional activities

- 2025 **Program Committee**, International Conference on Scale Space and Variational Methods in Computer Vision 2025
- 2024 **Co-organizer of a minisymposium**, SIAM Conference on Applied Linear Algebra  
Title: Operator Learning and Linear Algebra.
- 2023-2024 **Co-organizer of the Cambridge ACA seminar**
- 2023 **Co-organizer of a minisymposium**, 93rd GAMM Annual Meeting  
Title: Randomized algorithms in numerical linear algebra.
- 2022 **Highlighted Reviewer of ICLR 2022**
- 2021-date **Referee for several journals and conferences, including NeurIPS, ICML, ICLR, JMLR, and SISC.**
- 2021 **Co-organizer of a minisymposium**, SIAM Annual Meeting  
Title: Approximation theory of neural networks.

## Submitted papers

- 32. R. Sarfati, T. J.B. Liu, **N. Boullé**, and C. J. Earls, *What's in a prompt? Language models encode literary style in prompt embeddings*, submitted.
- 31. J. Rowbottom, S. Fresca, P. Lio, C.-B. Schönlieb, and **N. Boullé**, *Multi-Level Monte Carlo Training of Neural Operators*, submitted.
- 30. O. Zekri and **N. Boullé**, *Fine-Tuning Discrete Diffusion Models with Policy Gradient Methods*, submitted.
- 29. C. Runkel, S. Xiao, **N. Boullé**, and Y. Chen, *Operator learning regularization for macroscopic permeability prediction in dual-scale flow problem*, submitted.
- 28. O. Zekri, A. Odonnat, A. Benechehab, L. Bleistein, **N. Boullé**, and I. Redko, *Large Language Models as Markov Chains*, submitted.
- 27. N. Bouziani and **N. Boullé**, *Structure-Preserving Operator Learning*, submitted.

## Publications

- 26. T. J.B. Liu, **N. Boullé**, R. Sarfati, and C. J. Earls, *Visualizing in-context probability trajectories of LLMs*, ICLR (2025).
- 25. R. Sarfati, T. J.B. Liu, **N. Boullé**, and C. J. Earls, *Lines of Thought in Large Language Models*, ICLR (2025).
- 24. **N. Boullé** and M. Colbrook, *Multiplicative Dynamic Mode Decomposition*, SIAM J. Appl. Dyn. Syst. (2025).
- 23. D. Persson, **N. Boullé**, and D. Kressner, *Randomized Nyström approximation of non-negative self-adjoint operators*, SIAM J. Math. Data Sci. (2025).

22. T. J.B. Liu, **N. Boullé**, R. Sarfati, and C. J. Earls, *LLMs learn governing principles of dynamical systems, revealing an in-context neural scaling law*, EMNLP - Oral (2024).
21. **N. Boullé**, D. Halikias, S. E. Otto, and A. Townsend, *Operator learning without the adjoint*, J. Mach. Learn. Res. (2024).
20. **N. Boullé** and M. Colbrook, *On the Convergence of Hermitian Dynamic Mode Decomposition*, Physica D (2024).
19. **N. Boullé** and A. Townsend, *A Mathematical Guide to Operator Learning*, Handbook of Numerical Analysis (2024).
18. **N. Boullé**, A. Herremans, and D. Huybrechs, *Multivariate rational approximation of functions with curves of singularities*, SIAM J. Sci. Comput. (2024).
17. **N. Boullé**, D. Halikias, and A. Townsend, *Elliptic PDE learning is provably data-efficient*, PNAS (2023).
16. F. Laakmann and **N. Boullé**, *Bifurcation analysis of a two-dimensional magnetic Rayleigh-Bénard problem*, Physica D (2024).
15. H. Praveen, **N. Boullé**, and C. Earls, *Principled interpolation of Green's functions learned from data*, Comput. Methods Appl. Mech. Eng. (2023).
14. **N. Boullé**, I. Newell, P. E. Farrell, and P. G. Kevrekidis, *Two-Component 3D Atomic Bose-Einstein Condensates Supporting Complex Stable Patterns*, Phys. Rev. A (2023).
13. **N. Boullé**, S. Kim, T. Shi, and A. Townsend, *Learning Green's functions associated with parabolic partial differential equations*, J. Mach. Learn. Res. (2022).
12. **N. Boullé**, P. E. Farrell, and M. E. Rognes, *Optimal control of Hopf bifurcations*, SIAM J. Sci. Comput. (2023).
11. **N. Boullé**, P. E. Farrell, and A. Paganini, *Control of bifurcation structures using shape optimization*, SIAM J. Sci. Comput. (2022).
10. **N. Boullé** and A. Townsend, *A generalization of the randomized singular value decomposition*, ICLR (2022).
9. **N. Boullé**, C. J. Earls, and A. Townsend, *Data-driven discovery of Green's functions with human-understandable deep learning*, Sci. Rep. (2022).
8. **N. Boullé**, V. Dallas, and P. E. Farrell, *Bifurcation analysis of two-dimensional Rayleigh-Bénard convection using deflation*, Phys. Rev. E (2022).
7. A. Ellingsrud, **N. Boullé**, P. E. Farrell, and M. E. Rognes, *Accurate numerical simulation of electrodiffusion and osmotic water movement in brain tissue*, Math. Med. Biol. (2021).
6. **N. Boullé** and A. Townsend, *Learning elliptic partial differential equations with randomized linear algebra*, Found. Comput. Math. (2022).
5. **N. Boullé**, E. G. Charalampidis, P. E. Farrell, and P. G. Kevrekidis, *Deflation-based identification of nonlinear excitations of the three-dimensional Gross-Pitaevskii equation*, Phys. Rev. A (2020).
4. **N. Boullé**, Y. Nakatsukasa, and A. Townsend, *Rational neural networks*, NeurIPS (2020).
3. E. G. Charalampidis, **N. Boullé**, P. E. Farrell, and P. G. Kevrekidis, *Bifurcation analysis of stationary solutions of two-dimensional coupled Gross-Pitaevskii equations using deflated continuation*, Commun. Nonlinear Sci. Numer. Simulat. (2020).

2. **N. Boullé** and A. Townsend, *Computing with functions in the ball*, SIAM J. Sci. Comput. (2020).
1. **N. Boullé**, V. Dallas, Y. Nakatsukasa, and D. Samaddar, *Classification of chaotic time series with deep learning*, Physica D (2020).

## Technical reports

3. **N. Boullé**, J. Słomka, and A. Townsend, *An optimal complexity spectral method for Navier–Stokes simulations in the ball*, arXiv:2103.16638, 2021.
2. D. Barton, **N. Boullé**, E. Campillo-Funollet, C. Hall, S. Ruangdech, and Y. Zhou, *Compressing aerodynamic hazard data* (with Zenotech), ESGI 162, 2020.
1. E. Campillo-Funollet, **N. Boullé**, M. Ebeling-Rump, A. Pichler, A. Farid, M. P. Goodridge, H. Lee, B. Lyu, and M. Sejeso, *Uncertainty in seismic inverse problems* (with BP), ESGI 145, 2019.

## Academic visits and talks

<b>Householder Symposium XXII</b> , plenary speaker, Ithaca, USA.	June 2025
<b>University of Manchester</b> , Manchester, UK.	May 2025
<b>AIMS Rwanda</b> , Kigali, Rwanda.	April 2025
<b>ETH Zurich</b> , invited by Rima Alaifari, Zurich, Switzerland.	March 2025
<b>Ensta Paris</b> , Paris, France.	March 2025
<b>University of Oxford</b> , Oxford, UK.	January 2025
<b>Maxwell Institute</b> , Edinburgh, UK.	November 2024
<b>California Institute of Technology</b> , Los Angeles, USA.	November 2024
<b>University of British Columbia</b> , Vancouver, Canada.	November 2024
<b>Simon Fraser University</b> , Vancouver, Canada.	November 2024
<b>Oberwolfach workshop on Inverse Problems</b> , Germany.	October 2024
<b>Imperial-UCL Numerics Seminar</b> , London, UK.	October 2024
<b>CNRS Besançon</b> , Besançon, France.	October 2024
<b>I-X Imperial College London Seminar</b> , London, UK.	October 2024
<b>Firedrake 2024 Conference</b> , Oxford, UK.	September 2024
<b>Huawei Workshop</b> , invited speaker, Bordeaux, France.	September 2024
<b>Workshop on ML in infinite dimensions</b> , invited speaker, Bath, UK.	August 2024
<b>4th Symposium on ML and Dynamical Systems</b> , invited speaker, Canada.	July 2024
<b>Cornell University</b> , USA.	June 2024
<b>Grenoble AI for Sciences Workshop</b> , keynote speaker, France.	May 2024
<b>SIAM Conference on Applied Linear Algebra</b> , prize lecture, France.	May 2024
<b>Alan Turing Institute</b> , online seminar.	May 2024
<b>University of Bath</b> , Numerical Analysis seminar, UK.	April 2024
<b>One World Mathematics of Machine Learning</b> , online seminar.	April 2024
<b>Dynamics, Data and Deep learning workshop</b> , invited speaker, UK.	March 2024
<b>SCML2024 Conference</b> , invited speaker, Japan.	March 2024
<b>Inria Strasbourg</b> , invited by Victor Michel-Dansac, France.	February 2024
<b>University of Cambridge</b> , M4DL Workshop.	January 2024
<b>University of Birmingham</b> , Applied Mathematics Seminar.	January 2024
<b>Lawrence Livermore National Laboratory</b> , DDPS Webinar.	December 2023
<b>UCLouvain</b> , invited by Estelle Massart, Belgium.	October 2023
<b>Johns Hopkins University</b> , online Postdoc Seminar.	September 2023
<b>Maths4DL Conference</b> , invited speaker, UK.	July 2023
<b>29th Biennial Numerical Analysis Conference</b> , UK.	June 2023
<b>Brown University</b> , invited by Brendan Keith, USA.	June 2023
<b>British Applied Mathematics Colloquium</b> , UK.	April 2023
<b>UCL</b> , Math4DL workshop.	March 2023
<b>SIAM Conference on Computational Science and Engineering</b> , Netherlands.	February 2023
<b>KU Leuven</b> , invited by Daan Huybrechs, Belgium.	February 2023
<b>The Alan Turing Institute</b> , Oden-Turing workshop.	January 2023
<b>University of Cambridge</b> , CIA seminar.	November 2022

<b>The Alan Turing Institute</b> , UK.	November 2022
<b>University of Leicester</b> , CMS Mathematics seminar.	November 2022
<b>EPFL</b> , invited by Daniel Kressner, Switzerland.	October 2022
<b>Imperial College</b> , Numerics & Acoustics Workshop.	September 2022
<b>BIFD conference</b> , Netherlands.	August 2022
<b>Equadiff 15 conference</b> , Czech Republic.	July 2022
<b>University of Cambridge</b> , invited by Carola Schönlieb.	June 2022
<b>IMA Conference on Numerical Linear Algebra and Optimization</b> , Birmingham.	June 2022
<b>Householder Symposium on Numerical Linear Algebra</b> , Italy.	June 2022
<b>University of Oxford</b> , Numerical Analysis seminar.	May 2022
<b>ICLR 2022 conference</b> , online.	April 2022
<b>SIAM Conference on Uncertainty Quantification</b> , online.	April 2022
<b>Virtual study group</b> , V-KEMS.	March 2022
<b>STEM for Britain</b> , UK House of Commons.	March 2022
<b>Cornell University</b> , invited by Alex Townsend, USA.	February 2022
<b>PRISM Residential workshop</b> , UK.	January 2022
<b>SIAM UKIE Annual Meeting</b> , online.	January 2022
<b>University of Oxford</b> , Junior Applied Mathematics Seminar.	October 2021
<b>11th Montreal Industrial Problem Solving Workshop</b> , online.	August 2021
<b>SIAM Annual Meeting</b> , online.	July 2021
<b>British Early Career Mathematicians' Colloquium</b> , online.	July 2021
<b>20th IMA Leslie Fox Prize Event</b> , online.	June 2021
<b>21st Geilo Winter School</b> , online.	January 2021
<b>NeurIPS 2020 conference</b> , online.	December 2020
<b>University of Oxford</b> , Numerical Analysis seminar.	November 2020
<b>European Study Group with Industry 162</b> , University of Leeds.	July 2020
<b>Simula Research Laboratory</b> , visiting Marie Rognes, Norway.	August-September 2019
<b>European Study Group with Industry 145</b> , University of Cambridge.	April 2019
<b>University of Oxford</b> , Numerical Analysis seminar.	October 2018
<b>MIT</b> , visiting Jonasz Słomka, USA.	April 2018
<b>Cornell University</b> , SCAN seminar, USA.	November 2017
<b>Memorial University of Newfoundland</b> , visiting Alex Bihlo, Canada.	September 2017