

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 Matthew Colbrook), 2024-date.
- Kelan Gray (Imperial, with Matthew Colbrook), 2025-date.
- Jack Ross (Imperial, with Martin Rasmussen), 2025-date.
- Oussama Zekri (ENSAE Paris, with Anna Korba), 2025-date.

PhD graduates:

- Christina Runkel (Cambridge, with Carola Schönlieb), 2021-2025.

Undergraduate and MSc students: 18 undergraduate research projects or MSc dissertations at Imperial College London, University of Cambridge, University of Oxford, and Cornell University.

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-date **Editorial Board**, Numerical Functional Analysis and Optimisation.
- 2025-date **Co-organizer of the Imperial-UCL CCMI seminar**
- 2026 **Scientific Committee**, 5th IMA Conference on Inverse Problems from Theory to Application
- 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.
- 2021-date **Referee for international journals and conferences**, including NeurIPS, ICML, ICLR, JMLR, JCP, and SISC (highlighted reviewer of ICLR 2022).
- 2021 **Co-organizer of a minisymposium**, SIAM Annual Meeting
Title: Approximation theory of neural networks.

Invited and plenary talks

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| Chemnitz Summer School on Applied Analysis , invited speaker, Germany. | September 2026 |
| Workshop on Mathematics of data driven models , plenary speaker, Italy. | January 2026 |
| Workshop on Applications of NA and ML , plenary speaker, Amsterdam, NL. | December 2025 |
| Workshop on Infinite-dimensional ML , invited speaker, Zurich, Switzerland. | September 2025 |
| Householder Symposium XXII , plenary speaker, Ithaca, USA. | June 2025 |
| Huawei Lavender Summit , invited speaker, Bordeaux, France. | September 2024 |
| Workshop on ML in infinite dimensions , invited speaker, Bath, UK. | August 2024 |
| 4th Symposium on ML and Dynamical Systems , invited speaker, Canada. | July 2024 |
| Grenoble AI for Sciences Workshop , keynote speaker, France. | May 2024 |
| SIAM Conference on Applied Linear Algebra , prize lecture, France. | May 2024 |
| Dynamics, Data and Deep learning workshop , invited speaker, UK. | March 2024 |
| SCML2024 Conference , invited speaker, Japan. | March 2024 |
| Maths4DL Conference , invited speaker, UK. | July 2023 |

Submitted papers

- 36. O. Zekri, T. Uscidda, **N. Boullé**, and A. Korba, *Generalized Discrete Diffusion from Snapshots*, submitted.
- 35. T. J.B. Liu, B. Zadeoglu, R. Sarfati, **N. Boullé**, and C. J. Earls, *Jacobian Scopes: token-level causal*

attributions in LLMs, submitted.

- 34. J. Bao, **N. Boullé**, T. J.B. Liu, R. Sarfati, and C. J. Earls, *Text-Trained LLMs Can Zero-Shot Extrapolate PDE Dynamics*, submitted.
- 33. **N. Boullé**, M. Colbrook, and G. Conradie, *Convergent Methods for Koopman Operators on Reproducing Kernel Hilbert Spaces*, submitted.
- 32. C. Runkel, S. Xiao, **N. Boullé**, and Y. Chen, *Operator learning regularization for macroscopic permeability prediction in dual-scale flow problem*, submitted.
- 31. O. Zekri, A. Odonnat, A. Benechehab, L. Bleistein, **N. Boullé**, and I. Redko, *Large Language Models as Markov Chains*, submitted.
- 30. N. Bouziani and **N. Boullé**, *Structure-Preserving Operator Learning*, submitted.

Publications

- 29. 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*, EMNLP (2025).
- 28. J. Rowbottom, S. Fresca, P. Lio, C.-B. Schönlieb, and **N. Boullé**, *Multi-Level Monte Carlo Training of Neural Operators*, to appear in Comput. Methods Appl. Mech. Eng. (2026).
- 27. O. Zekri and **N. Boullé**, *Fine-Tuning Discrete Diffusion Models with Policy Gradient Methods*, NeurIPS (2025).
- 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. Sejso, *Uncertainty in seismic inverse problems* (with BP), ESGI 145, 2019.