

Nicolas Boullé

Research interests

Numerical analysis, machine learning, computational physics

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:

- Qile Jiang (Cornell REU summer project), 2023.
- Emily Zhang (Cornell REU summer project), 2023.
- Henry Smith (Yale undergraduate student), 2021-2022.
- Franklin Deng (Cornell REU summer project), 2021.

- Jack Krew (Cornell REU summer project), 2021.
- Markus Dablander (Oxford PhD student mini-project), 2020.

Teaching

- 2021 **Tutor for Approximation of functions**, Mathematical Institute, University of Oxford.
- 2020 **Tutor for Approximation of functions**, Mathematical Institute, University of Oxford.
- 2019 **TA for Practical Numerical Analysis**, Mathematical Institute, University of Oxford.
- 2019 **TA for Approximation of functions**, Mathematical Institute, University of Oxford.

Professional activities

- 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

- O. Zekri, A. Odonnat, A. Benezhehab, L. Bleistein, **N. Boullé**, and I. Redko, *Large Language Models as Markov Chains*, submitted.
- T. J.B. Liu, **N. Boullé**, R. Sarfati, and C. J. Earls, *Visualizing in-context probability trajectories of LLMs*, submitted.
- R. Sarfati, T. J.B. Liu, **N. Boullé**, and C. J. Earls, *Lines of Thought in Large Language Models*, submitted.
- N. Bouziani and **N. Boullé**, *Structure-Preserving Operator Learning*, submitted.
- N. Boullé** and M. Colbrook, *Multiplicative Dynamic Mode Decomposition*, submitted.
- D. Persson, **N. Boullé**, and D. Kressner, *Randomized Nyström approximation of non-negative self-adjoint operators*, submitted.
- N. Boullé** and M. Colbrook, *On the Convergence of Hermitian Dynamic Mode Decomposition*, submitted.

Publications

- 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 (2024).
- N. Boullé**, D. Halikias, S. E. Otto, and A. Townsend, *Operator learning without the adjoint*, J. Mach. Learn. Res. (2024).
- 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

I-X Imperial College London Seminar , London, UK.	October 2024
Firedrake 2024 Conference , Oxford, UK.	September 2024
Huawei Workshop , 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
Cornell University , USA.	June 2024
Grenoble AI for Sciences Workshop , keynote speaker, France.	May 2024
SIAM Conference on Applied Linear Algebra , Prize Lecture, France.	May 2024
Alan Turing Institute , online seminar.	May 2024
University of Bath , Numerical Analysis seminar, UK.	April 2024
One World Mathematics of Machine Learning , online seminar.	April 2024
Dynamics, Data and Deep learning workshop , invited speaker, UK.	March 2024
SCML2024 Conference , invited speaker, Japan.	March 2024
Inria Strasbourg , invited by Victor Michel-Dansac, France.	February 2024
University of Cambridge , M4DL Workshop.	January 2024
University of Birmingham , Applied Mathematics Seminar.	January 2024
Lawrence Livermore National Laboratory , DDPS Webinar.	December 2023
UCLouvain , invited by Estelle Massart, Belgium.	October 2023
Johns Hopkins University , online Postdoc Seminar.	September 2023
Maths4DL Conference , invited speaker, UK.	July 2023
29th Biennial Numerical Analysis Conference , UK.	June 2023
Brown University , invited by Brendan Keith, USA.	June 2023
British Applied Mathematics Colloquium , UK.	April 2023
UCL , Math4DL workshop.	March 2023
SIAM Conference on Computational Science and Engineering , Netherlands.	February 2023
KU Leuven , invited by Daan Huybrechs, Belgium.	February 2023
The Alan Turing Institute , Oden-Turing workshop.	January 2023
University of Cambridge , CIA seminar.	November 2022
The Alan Turing Institute , UK.	November 2022
University of Leicester , CMS Mathematics seminar.	November 2022
EPFL , invited by Daniel Kressner, Switzerland.	October 2022
Imperial College , Numerics & Acoustics Workshop.	September 2022
BIFD conference , Netherlands.	August 2022
Equadiff 15 conference , Czech Republic.	July 2022
University of Cambridge , invited by Carola Schönlieb.	June 2022
IMA Conference on Numerical Linear Algebra and Optimization , Birmingham.	June 2022
Householder Symposium on Numerical Linear Algebra , Italy.	June 2022
University of Oxford , Numerical Analysis seminar.	May 2022
ICLR 2022 conference , online.	April 2022
SIAM Conference on Uncertainty Quantification , online.	April 2022
Virtual study group , V-KEMS.	March 2022
STEM for Britain , UK House of Commons.	March 2022
Cornell University , invited by Alex Townsend, USA.	February 2022
PRISM Residential workshop , UK.	January 2022
SIAM UKIE Annual Meeting , online.	January 2022
University of Oxford , Junior Applied Mathematics Seminar.	October 2021
11th Montreal Industrial Problem Solving Workshop , online.	August 2021
SIAM Annual Meeting , online.	July 2021

British Early Career Mathematicians' Colloquium , online.	July 2021
20th IMA Leslie Fox Prize Event , online.	June 2021
21st Geilo Winter School , online.	January 2021
NeurIPS 2020 conference , online.	December 2020
University of Oxford , Numerical Analysis seminar.	November 2020
European Study Group with Industry 162 , University of Leeds.	July 2020
Simula Research Laboratory , visiting Marie Rognes, Norway.	August-September 2019
European Study Group with Industry 145 , University of Cambridge.	April 2019
University of Oxford , Numerical Analysis seminar.	October 2018
MIT , visiting Jonasz Słomka, USA.	April 2018
Cornell University , SCAN seminar, USA.	November 2017
Memorial University of Newfoundland , visiting Alex Bihlo, Canada.	September 2017