

Nicolas Boullé

Research Fellow at the University of Cambridge

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Research interests

Numerical analysis, machine learning, computational physics

Employment

2022-date **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

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 supervision

- Christina Runkel (Cambridge PhD student, mentored since 2023).
- Qile Jiang (Cornell REU summer project in 2023).
- Emily Zhang (Cornell REU summer project in 2023).
- Henry Smith (Yale undergraduate student, mentored in 2021-2022).
- Franklin Deng (Cornell REU summer project in 2021).
- Jack Krew (Cornell REU summer project in 2021).
- Markus Dablander (Oxford PhD student mini-project in Summer 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-date **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

- 21. **N. Boullé** and M. Colbrook, *On the Convergence of Hermitian Dynamic Mode Decomposition*, submitted.
- 20. **N. Boullé** and A. Townsend, *A Mathematical Guide to Operator Learning*, submitted.
- 19. **N. Boullé**, A. Herremans, and D. Huybrechs, *Multivariate rational approximation of functions with curves of singularities*, submitted.
- 18. F. Laakmann and **N. Boullé**, *Bifurcation analysis of a two-dimensional magnetic Rayleigh-Bénard problem*, submitted.
- 17. **N. Boullé**, J. Słomka, and A. Townsend, *An optimal complexity spectral method for Navier-Stokes simulations in the ball*, submitted.

Publications

- 16. **N. Boullé**, D. Halikias, and A. Townsend, *Elliptic PDE learning is provably data-efficient*, PNAS (2023).
- 15. **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).
- 14. H. Praveen, **N. Boullé**, and C. Earls, *Principled interpolation of Green's functions learned from data*, Comput. Methods Appl. Mech. Eng. (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).

Study group with industry reports

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

Lawrence Livermore National Laboratory , DDPS Webinar.	December 2023
UCLouvain , invited by Estelle Massart.	October 2023
Johns Hopkins University , online Postdoc Seminar.	September 2023
Maths4DL Conference , invited speaker.	July 2023
29th Biennial Numerical Analysis Conference , UK.	June 2023
Brown University , invited by Brendan Keith.	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.	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.	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.	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.	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.	April 2018
Cornell University , SCAN seminar.	November 2017
Memorial University of Newfoundland , visiting Alex Bihlo.	September 2017