CV: Matthew J. Colbrook

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Education

- October 2016 – September 2020: **University of Cambridge**, St John's College, UK
  PhD, Mathematics, Cambridge Centre for Analysis (CDT, Supervisor: Dr A. Hansen)
  Thesis: *The Foundations of Infinite-Dimensional Spectral Computations*
- Academic year 2015 – 2016: **University of Cambridge**, St John's College, UK
  MMath, Mathematics. Grade: Distinction.
  (Ranked 3rd in the year (out of > 200) and top in the Department of Applied Mathematics and Theoretical Physics (DAMTP))
- Summer 2015 (10 weeks): **Caltech**, USA
  Summer Undergraduate Research Fellowship
  (Supervisor: Professor Philip Hopkins, Outcome: Published article in Monthly Notices of the Royal Astronomical Society)
- October 2012 – July 2015: **University of Cambridge**, St John's College, UK
  BA (Hons), Mathematics. Grade: 1st every year.

Academic Positions

- October 2020 – present: **Junior Research Fellow, Trinity College, University of Cambridge**, UK

Main Academic Prizes and Awards

- Cecil King Travel Scholarship 2020
  (an annual prize of the London Mathematical Society "to a young mathematician of outstanding promise")
- IMA Lighthill–Thwaites Prize Finalist 2019
  (biannual international prize given by IMA to early career (PhD/postdoc) applied mathematicians)
- Grade 1 Smith–Knight/Rayleigh–Knight Prize 2018
  (annual prize for best first-year graduate piece of research in the mathematics department at the University of Cambridge)
- Mayhew Prize 2016
  (annual prize given to best DAMTP MMath degree at the University of Cambridge)
- LMS Travel Grant for Early Career Researchers 2020
- Caltech SURF Scholarship 2015
- Cambridge Summer Research in Mathematics 2014 (grant for undergraduate academic research project)
- Baylis Scholarship for Mathematics 2013–2016
- Various named College Prizes for exceptional exam results 2013–2016.

Research Interests

Spectral computations in infinite dimensions and infinite-dimensional numerical linear algebra, computational PDEs including spectral and pseudospectral methods, analysis and numerical solutions of initial boundary value problems, deep learning and its mathematical foundations, computational fluid mechanics and acoustic scattering problems

Publications

(***** denotes articles which are predominantly my work and where I am the lead author)

Peer-reviewed journal articles:

1. M.J. Colbrook*****, B. Roman, A.C. Hansen, *How to compute spectra with error control*, **Physical Review Letters**, 2019. (Cover highlight for issue and winner of **Grade 1 Smith–Knight/Rayleigh–Knight Prize 2018**)
2. M.J. Colbrook, A. Horning, A. Townsend, *Computing spectral measures of self-adjoint operators*, **SIAM Review**, to appear.
3. M.J. Colbrook*****, *Extending the unified transform: curvilinear polygons and variable coefficient PDEs*, **IMA Journal of Numerical Analysis**, 2020.
4. M.J. Colbrook*****, A.C. Hansen, *On the infinite-dimensional QR algorithm*, **Numerische Mathematik**, 2019.
5. M.J. Colbrook*****, T. Fokas, P. Hashemzadeh, *A hybrid analytical-numerical technique for elliptic PDEs*, **SIAM Journal on Scientific Computing**, 2019.
6. M.J. Colbrook*****, N. Flyer, B. Fornberg, *On the Fokas method for the solution of elliptic problems in both convex and non-convex polygonal domains*, **Journal of Computational Physics**, 2018.
7. M.J. Colbrook*****, *Pseudoergodic operators and periodic boundary conditions*, **Mathematics of Computation**, 2020.
8. M.J. Colbrook*****, L.J. Ayton, T. Fokas, *The unified transform for mixed boundary condition problems in unbounded domains*, **Proceedings of the Royal Society A**, 2019. (**IMA Lighthill–Thwaites Prize Finalist 2019**)
9. M.J. Colbrook*****, A. Kisil, *A Mathieu function boundary spectral method for diffraction by multiple variable poro-elastic plates, with applications to metamaterials and acoustics*, **Proceedings of the Royal Society A**, 2020.
10. M.J. Colbrook*****, L.J. Ayton, *A spectral collocation method for acoustic scattering by multiple elastic plates*, **Journal of Sound and Vibration**, 2019.
11. M.J. Colbrook*****, L.J. Ayton, *Do we need non-linear corrections? On the boundary Forchheimer equation in acoustic scattering*, **Journal of Sound and Vibration**, 2020.
12. M.J. Colbrook*****, Z.I. Botev, K. Kuritz, S. MacNamara, *Kernel density estimation with linked boundary conditions*, **Studies in Applied Mathematics**, 2020.
13. M.J. Colbrook, M.J. Priddin, *Fast and spectrally accurate numerical methods for perforated screens*, **IMA Journal of Applied Mathematics**, 2020.

14. L.J. Ayton, M.J. Colbrook, T. Geyer, P. Chaitanya, E. Sarradj, *Reducing aerofoil-turbulence interaction noise through chordwise-varying porosity*, **Journal of Fluid Mechanics**, 2021.
15. M.J. Colbrook*****, X. Ma, P. Hopkins, J. Squire, *Scaling laws of passive-scalar diffusion in the interstellar medium*, **Monthly Notices of the Royal Astronomical Society**, 2017.
16. F. de Barros, M.J. Colbrook, T. Fokas, *A hybrid analytical-numerical method for solving advection-dispersion problems on a half-line*, **International Journal of Heat and Mass Transfer**, 2019.

Peer-reviewed conference articles:

C1. L.J. Ayton, M.J. Colbrook, T. Fokas, *The unified transform: a spectral collocation method for acoustic scattering*, **AIAA/CEAS Aeroacoustics**, 2019.

C2. M.J. Colbrook*****, V. Antun, A.C. Hansen, *On the existence of stable and accurate neural networks for image reconstruction*, **Signal Processing with Adaptive Sparse Structured Representations**, 2019.

Selected submitted articles and preprints (available on the arXiv or on my website):

S1. M.J. Colbrook*****, A.C. Hansen, *The foundations of spectral computations via the solvability complexity index hierarchy:Part 1.*

S2. M.J. Colbrook*****, *On the computation of geometric features of spectra of linear operators on Hilbert spaces.*

S3. M.J. Colbrook*****, *Computing spectral measures and spectral types.*

S4. J. Ben-Artzi, M.J. Colbrook, A.C. Hansen, O. Nevanlinna, M. Seidel, *Computing Spectra - On the solvability complexity index hierarchy and towers of algorithms.*

S5. V. Antun, M.J. Colbrook, A.C. Hansen, *Can stable and accurate neural networks be computed? - On the barriers of deep learning and Smale's 18th problem.*

Selected lectures, and talks/papers at conferences/workshops

- Jan 2021: "*On the barriers of AI and the trade-off between stability and accuracy in deep learning*," lectures given at the 21st Geilo Winter School in eScience.
- Dec 2020: "*Diagonalising Infinite-Dimensional Operators: Computing spectral measures of self-adjoint operators*," Annual Meeting of the Australian Mathematical Society.
- Dec 2020: "*A Mathieu function boundary spectral method for acoustic scattering*," Canadian Mathematical Society Winter Meeting.
- Oct 2020: "*Diagonalising Infinite-Dimensional Operators: Computing spectral measures of self-adjoint operators*," Communications in NLA (Online Seminar Series).
- Sep 2020: "*How To Compute Spectra With Error Control*," Computational Techniques & Applications Conference, University of New South Wales, Australia. **Student prize:** Selected as highly commended.
- July 2020: "*The Foundations of Infinite-Dimensional Spectral Computations*," British Early Career Mathematicians' Colloquium.
- May 2020: "*Scattering, Acoustic Black Holes and Mathieu Functions: A boundary spectral method for diffraction by multiple variable poro-elastic plates*," Waves in Complex Continua, International Centre for Mathematical Sciences.
- Dec 2019: "*The Foundations of Infinite-Dimensional Spectral Computations*," INI workshop on complex analysis.
- Aug 2019: "*Solving Wiener–Hopf problems numerically: a spectral method approach*," INI workshop on Wiener–Hopf technique.
- July 2019: "*Do stable networks with recovery guarantees exist?*" Applied Inverse Problems Conference, Grenoble, France.
- June 2019: "*Spectral analysis and new resolvent based methods*," Biennial Numerical Analysis Conference, Glasgow, UK.
- May 2019: "*On Instabilities of Deep Learning in Image Reconstruction*," INI workshop on deep learning and data science.
- April 2019: "*The Unified Transform: A New Tool for Scattering Problems*," British Applied Mathematics Colloquium, Bath, UK.
- Sep 2018: "*On the solvability complexity index hierarchy, the computational spectral problem and computer-assisted proofs*," Measuring the Complexity of Computational Content, Dagstuhl, Germany.

Selected upcoming future talks

- **Plenary Speaker:** "*The Foundations of Infinite-Dimensional Spectral Computations*," Będlewo Acta Numerica Conference (celebrating 30 years of Acta Numerica), June 2021 (delayed until 2022 due to COVID-19).
- "*Can stable and accurate neural networks be computed? - On the barriers of deep learning and Smale's 18th problem*," SIAM Annual Meeting, July 2021.

Selected seminar talks

Over 10 invited seminar talks over the last few years including at: Cornell University (Scientific Computing and Numerics Seminar), Imperial College London (Imperial–UCL Numerics Seminar), University of Bath (Applied and Interdisciplinary Mathematics Seminar & Numerical Analysis Seminar), UC Berkeley (Analysis Seminar, Applied Mathematics Seminar), UC Irvine (Applied and Computational Mathematics Seminar), University of Oxford (Oxford–Cambridge Applied Mathematics Meeting), University of Washington (Applied PDE Seminar), École Normale Supérieure (Laplace Seminar Series) and École Polytechnique Fédérale de Lausanne (Biomedical Imaging Seminar).

Lecturing, teaching and administrative roles

- January 2021: Lecturer on machine learning at the 21st Geilo Winter School.
- Supervised Cambridge undergraduate courses on numerical analysis, mathematical methods, machine learning, analysis, statistics and linear algebra.
- Taught exam revision lectures for University of Cambridge MMath degree courses.
- Conducted admissions interviews for undergraduates in mathematics for Homerton College, Cambridge.
- 2018: Supervised a student intern research project on the unified transform.
- 2018: Ran the Cambridge Analysts' Knowledge Exchange seminar series.
- 2019/2020: Ran a joint PhD seminar series between the Cambridge and Imperial numerical analysis groups.

Refereed for: Applied Mathematics Letters, Foundations of Computational Mathematics, IMA Journal of Numerical Analysis, Journal of Aerospace Engineering, Journal of Applied Analysis and Computation, Journal of Computational Physics, Journal of Fourier Analysis and Applications, Journal of Scientific Computing, Nature Scientific Reports, Proceedings of the Royal Society A, SIAM Journal on Applied Mathematics, Studies in Applied Mathematics, Transactions on Knowledge and Data Engineering, Transactions on Pattern Analysis and Machine Intelligence, Zeitschrift für Naturforschung A, Cambridge University Press (book).