

**Alex Townsend**  
**Goenka Family Tenure-Track Assistant Professor, Cornell University**

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**Research resume**

Numerical analysis and scientific computing. My research focuses on spectral methods, low rank approximation, fast transforms, and polynomial system solving.

**Education**

**DPhil in Numerical Analysis**      University of Oxford      Oct 2010 – July 2014  
Supervised by Prof. L. N. Trefethen FRS  
Thesis title: *Computing with functions in two dimensions*

**MMath Mathematics**      University of Oxford      Oct 2006 – July 2010  
Awarded 1st class degree (ranked 2nd in the year)

**Professional experience**

**Assistant Professor**      Cornell University      July 2016 – Present  
Taught MATH 2220: Multivariable calculus  
MATH 2930: Differential equations for engineers  
MATH 2940: Linear algebra for engineers  
MATH 4250: Numerical analysis and ODEs  
[MATH 7270: Top-ten algorithms of the 20th century](#)  
MATH 6220: Applied functional analysis

**Applied Math Instructor**      MIT      Aug 2014 – June 2016  
Taught 18.336: Fast Numerical methods for PDEs  
18.085: Computational Science and Engineering  
18.06: Linear Algebra

**Adjunct Instructor**      Courant Institute      Sept 2013 – Oct 2013  
Tutored: Approximation Theory and Approximation Practice

**Honors and prizes**

- [SIGEST award from SIAM Review](#) for “The singular values of matrices with displacement structure” in 2019
- Junior Faculty Teaching Award from Cornell Math Department in 2018
- [The SIAM Activity Group on Linear Algebra Early Career Prize in 2018](#)
- [Leslie Fox prize \(1st place\)](#) for work on the discrete Hankel transform in 2015
- [Leslie Fox prize \(2nd place\)](#) for work on the ultraspherical spectral method in 2013
- SIAM UKIE prize for the best student research talk in 2011
- Junior Mathematics Prize in 2008 and 2009, and IMA prize in 2009 and 2010. Awarded through the University of Oxford for top undergraduate examination results

## Research and curriculum grants

- NSF DMS-1952757 (lead PI): July 2020 to June 2023.
- Data Science Curriculum Initiative grant (lead PI): Sept. 2019 to Sept. 2021.
- FACE Foundation (lead PI): Sept. 2019 to Aug. 2021
- [NSF DMS-1818757](#) (sole PI): June 2018 to July 2021
- [Engaged Cornell curriculum grant](#) (lead PI): Sept. 2018 to Aug. 2020
- [NSF DMS-1645445](#) (sole PI): Aug. 2015 to July 2018.

## Current graduate students

[Nicolas Boulle](#) (DPhil at University of Oxford in Mathematics, joint with Patrick Farrell, due to graduate in May 2022)

[Andrew Horning](#) (CAM graduate student, due to graduate in May 2021)

[Tianyi Shi](#) (CAM graduate student, due to graduate in May 2022)

[Heather Wilber](#) (CAM graduate student, due to graduate in May 2021)

## Past students

Jane Du (Msc student in CS in 2019-2020)

[Marc Gilles](#) (Cornell graduate student, graduated May 2019)

[Dan Fortunato](#) (Harvard graduate student in SEAS, joint with Chris Rycroft, graduated August 2020)

Diego Antolin–Ruiz (Cornell intern in 2016)

David Darrow (MIT PRIMES student in 2018)

Sujit Rao (Cornell undergraduate, mentored in 2018)

Xingrun Xing (Intern from Shanghai Jiao Tong University in 2019)

[Aaron Yeiser](#) (MIT PRIMES student in 2017)

## Journal publications

- [38] M. SLEVINSKY, S. OLVER, AND A. TOWNSEND, *Fast algorithms with orthogonal polynomials*, Acta Numerica, 2020.
- [37] M. J. COLBROOK, A. HORNING, AND A. TOWNSEND, *Computing spectral measures of self-adjoint operators*, to appear in SIAM Review, 2021.
- [36] D. FORTUNATO, N. HALE, AND A. TOWNSEND, *The ultraspherical spectral element method*, to appear in J. Comput. Phys., 2021.
- [35] T. SHI AND A. TOWNSEND, *On the compressibility of tensors*, to appear in SIAM J. Mat. Anal. Appl., 2021.
- [34] N. BOULLÉ, Y. NAKATSUKASA, AND A. TOWNSEND, *Rational neural networks*, NeurIPS, 33 (2020).
- [33] Y. NAKATSUKASA AND A. TOWNSEND, *Error localization of best  $L_1$  polynomial approximants*, to appear in SIAM J. Numer. Anal., 2020.
- [32] A. TOWNSEND, M. STILLMAN, AND S. H. STROGATZ, *Dense networks that do not synchronize and sparse ones that do*, Chaos, 30 (2020), 083142.
- [31] N. BOULLE AND A. TOWNSEND, *Computing with functions on the ball*, SIAM J. Sci. Comput., 42 (2020), C169–C191.
- [30] A. HORNING AND A. TOWNSEND, *FEAST for differential eigenvalue problems*, SIAM J. Numer. Anal., 58 (2020), pp. 1239–1262.

- [29] S. OLVER, A. TOWNSEND, AND G. M. VASIL, *Recurrence relations for a family of orthogonal polynomials on a triangle*, ICOSAHOM Proceedings, Springer 2020, pp. 79–92.
- [28] D. FORTUNATO AND A. TOWNSEND, *Fast Poisson solvers for spectral methods*, IMA Numer. Anal, 40 (2020), pp. 1994–2018.
- [27] S. OLVER, A. TOWNSEND, AND G. VASIL, *A sparse spectral method on triangles*, SIAM J. Sci. Comput., 41 (2019), A3728–3756.
- [26] K. N. QUINN, H. WILBER, A. TOWNSEND, AND J. P. SETHNA, *Chebyshev approximation and the global geometry of sloppy models*, Physical Review Letters, 122, 158302.
- [25] M. A. GILLES AND A. TOWNSEND, *Continuous analogues of Krylov methods for differential operators*, SIAM J. Numer. Anal., 57 (2019), pp. 899–924.
- [24] B. BECKERMANN AND A. TOWNSEND, *Bounds on the singular values of matrices with displacement structure*, SIAM Review, 61 (2019), pp. 319–344.
- [23] M. UDELL AND A. TOWNSEND, *Why are big data matrices approximately of low rank?*, SIAM J. Math. Data Sci., 1 (2019), pp. 144–160.
- [22] J. SŁOMKA, A. TOWNSEND, AND J. DUNKEL, *Stokes’ second problem and an Einstein-de Haas analogue effect in active fluids*, Physical Review Fluids, 3 (2018).
- [21] A. TOWNSEND AND H. WILBER, *On the singular values of matrices with high displacement rank*, Linear Alg. Appl., 548 (2018), pp. 19–41.
- [20] D. ANTOLN–RUIZ AND A. TOWNSEND, *A nonuniform fast Fourier transform based on low rank approximation*, SIAM J. Sci. Comput., 40 (2018), A529–A547.
- [19] A. TOWNSEND, M. WEBB, AND S. OLVER, *Fast polynomial transforms based on Toeplitz and Hankel matrices*, Math. Comp., 87, (2018).
- [18] B. BECKERMANN AND A. TOWNSEND, *On the singular values of matrices with displacement structure*, SIAM J. Mat. Anal. Appl., 38 (2017), pp. 1227–1248.
- [17] A. TOWNSEND, H. WILBER, AND G. B. WRIGHT, *Computing with functions in spherical and polar geometries II. The disk*, SIAM J. Sci. Comput., 39 (2017), C238–C262.
- [16] L. DEMANET AND A. TOWNSEND, *Stable extrapolation of analytic functions*, Found. Comput. Math., (2016), pp. 1–35.
- [15] V. NOFERINI, Y. NAKATSUKASA, AND A. TOWNSEND, *Vector spaces of linearizations for matrix polynomials: A bivariate polynomial approach*, SIAM J. Mat. Anal. Appl., 38 (2016), pp. 1–29.
- [14] N. HALE AND A. TOWNSEND, *A fast FFT-based discrete Legendre transform*, IMA Numer. Anal., 36 (2016), pp. 1670–1684.
- [13] A. TOWNSEND, H. WILBER, AND G. B. WRIGHT, *Computing with functions in spherical and polar geometries I. The sphere*, SIAM J. Sci. Comput., 38 (2016), C403–C425.
- [12] V. NOFERINI AND A. TOWNSEND, *Numerical instability of resultant methods for multidimensional rootfinding*, SIAM J. Numer. Anal., 54 (2016), pp. 719–743.
- [11] A. TOWNSEND, T. TROGDON, AND S. OLVER, *Fast computation of Gauss quadrature nodes and weights on the whole real line*, IMA Numer. Anal., 36 (2016), pp. 337–358.
- [10] A. TOWNSEND AND S. OLVER, *The automatic solution of partial differential equations using a global spectral method*, J. Comp. Phys., 299 (2015), pp. 106–123.

- [9] A. TOWNSEND, *A fast analysis-based discrete Hankel transform using asymptotic formulas*, SIAM J. Numer. Anal., 53 (2015), pp. 1897–1917.
- [8] Y. NAKATSUKASA, V. NOFERINI, AND A. TOWNSEND, *Computing the common zeros of two bivariate functions via Bézout resultants*, Numer. Math., 129 (2015), pp. 181–209.
- [7] A. TOWNSEND AND L. N. TREFETHEN, *Continuous analogues of matrix factorizations*, Proc. Roy. Soc. A., 471 (2015).
- [6] N. HALE AND A. TOWNSEND, *An algorithm for the convolution of Legendre series*, SIAM J. Sci. Comput., 36 (2014), A1207–A1220.
- [5] N. HALE AND A. TOWNSEND, *A fast, simple, and stable Chebyshev–Legendre transform using an asymptotic formula*, SIAM J. Sci. Comput., 36 (2014), A148–A167.
- [4] A. TOWNSEND AND L. N. TREFETHEN, *An extension of Chebfun to two dimensions*, SIAM J. Sci. Comput., 35 (2013), C495–C518.
- [3] N. HALE AND A. TOWNSEND, *Fast and accurate computation of Gauss–Legendre and Gauss–Jacobi quadrature nodes and weights*, SIAM J. Sci. Comput., 35 (2013), A652–A672.
- [2] S. OLVER AND A. TOWNSEND, *A fast and well-conditioned spectral method*, SIAM Review, 55 (2013), pp. 462–489.
- [1] A. TOWNSEND AND H. WENDLAND, *Multiscale analysis in Sobolev spaces on bounded domains with zero boundary values*, IMA J. Numer. Anal., 33 (2013), pp. 1095–1114.

### Submitted papers, conference proceedings, and technical reports

- A. BENSON, A. DAMLE, AND A. TOWNSEND, *Over-parametrized neural networks as under-determined linear systems*, submitted to SIAM J. Math. Data Sci.
- D. RUBIN, A. TOWNSEND, AND H. WILBER, *Bounding Zolotarev numbers using Faber rational functions*, submitted to Constr. Approx.
- Y. YANG, A. TOWNSEND, AND D. APPELÖ, *Anderson acceleration using the  $\mathcal{H}^{-s}$  norm*, submitted to J. Comput. Appl. Math.
- G. LI, A. TOWNSEND, L. A. ARCHER, AND D. L. KOCH, *Electroconvection and Electrodeposition on a Surface with Butler–Volmer Kinetics*, submitted to J. Fluid Mechanics.
- G. LI, A. TOWNSEND, L. A. ARCHER, AND D. L. KOCH, *Suppression of electroconvective and morphological instabilities by an imposed cross flow of the electrolyte*, submitted to Phys. Rev. J.
- S. OLVER AND A. TOWNSEND, *A practical framework for infinite-dimensional linear algebra*, First Workshop for High Performance Technical Computing in Dynamic Languages, in IEEE conference proceedings, 2014.

### Other articles

- A. TOWNSEND, *A review of “Orthogonal Polynomials in MATLAB” by Gautschi*, SIAM Review, 59 (2017), pp. 463–464.
- A. TOWNSEND, *A review of “A Graduate Introduction to Numerical Methods” by Corless and Fillion*, SIAM Review, 58 (2016), pp. 795–798.
- A. TOWNSEND, *The race for high order Gauss–Legendre quadrature*, SIAM News, March 2015.

A. TOWNSEND AND L. N. TREFETHEN, *Gaussian elimination as an iterative algorithm*,  
SIAM News, March 2013.

### Presentations at conferences and workshops (since 2017)

2020 Canadian Mathematical Society Winter Meeting, online	December 2020
SIAM Mathematical Data Science, online	June 2020
ICIAM2019 in Valencia	July 2019
29th Biennial Numerical Analysis conference in Strathclyde	June 2019
Approximation Theory 16, Nashville	May 2019
Software and Mathematics of spectral methods, London	July 2018
Algebra meets Numerics: conditioning and complexity in TU Berlin	Nov 2017
27th Biennial Numerical Analysis conference in Strathclyde	June 2017
SIAM Computational Science & Engineering in Atlanta	March 2017

### Invited presentations (since 2017)

AIM seminar at University of Michigan	October 2020
Pacific Northwest Numerical Analysis Seminar, Keynote speaker	October 2020
CTAC2020 plenary talk, online	September 2020
Berkeley, Applied Math Colloquium (invited by Lin Lin)	September 2020
Householder 2020 plenary talk (postponed)	June 2020
University of Oxford, NA seminar (invited by Nick Trefethen)	May 2020
CRM, University of Montreal (invited by Jean-Philippe Lessard)	April 2020
Isaac Newton Institute at Cambridge University	December 2019
UW Madison, Colloquium (invited by Qin Li)	October 2019
Rensselaer Polytechnic Institute, Keynote talk for RPI day	May 2019
UT Austin, Colloquium (invited by Gunnar Martinsson)	April 2019
Princeton University, Colloquium (invited by Amit Singer)	February 2019
NII in Tokyo (invited by Yuji Nakatsukasa)	December 2018
ICOSAHOM 2018, plenary speaker	July 2018
BYU (invited by Tyler Jarvis)	April 2018
Courant Institute, Applied Math seminar (invited by Michael Overton)	April 2018
MIT student Engineering symposium, keynote speaker	March 2018
University of Maryland, Colloquium (invited by Howard Elman)	Nov 2017
Temple University, Colloquium (invited by Daniel Szyld)	Nov 2017
KU Leuven, Numerical seminar talk (invited by Daan Huybrechs)	Nov 2017
NJIT, Colloquium (invited by Michael Booty)	Sept 2017
Plenary lecture at Householder conference	June 2017
NCAR workshop on multiscale geoscience (invited by Natasha Flyer)	May 2017

## Professional activities

Referee for numerous journals, including SIAM Review, SINUM, SIMAX, SISC, JCOMP, and Numerische Mathematik. Also referee for SIAM Books and Cambridge University Press.

Judging panel for National Science Foundation grant proposals in 2016, 2017, and 2019.

Co-organize an [undergraduate math modeling competition](#) at Cornell with engagement from the local community and businesses. Lead PI on [Engaged Cornell curriculum grant](#) and the lead PI on the data science curriculum initiative in Arts & Sciences at Cornell University.

Math consultant for the two episodes of PBS infinite series [“Why Computers are Bad at Algebra”](#) and [“How to Generate Pseudorandom Numbers”](#).

Co-organizer for the [“New Directions in Numerical Computing”](#) in 2015 conference and the Numerical linear algebra workshop in [“Foundations of Computational Mathematics: Numerical Linear Algebra”](#) in 2017. Along with a dozen or so minisymposia at conferences.