John Urschel

Contact Information

Massachusetts Institute of Technology
Department of Mathematics
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Citizenship Canada, USA

Research Interests matrix analysis, numerical analysis, spectral graph theory

Current Appointments

Massachusetts Institute of Technology, Department of Mathematics

Assistant Professor, 2023-Present

Harvard University, Society of Fellows

Junior Fellow, 2022-Present

Previous Appointments

Institute for Advanced Study, School of Mathematics

Member, 2021-2022

Education

Massachusetts Institute of Technology, Department of Mathematics

Ph.D. in Mathematics, 2021
Thesis: Graphs, Principal Minors, and Eigenvalue Problems
Advisor: Michel Goemans

Pennsylvania State University, Department of Mathematics

M.A. in Mathematics, 2013
Thesis: Graph-Based Topics in Applied Mathematics
Advisors: Victor Nistor, Jinchao Xu, Ludmil Zikatanov

Pennsylvania State University, Department of Mathematics

B.S. in Mathematics, 2012
Minor in Statistics

Honors and Awards

2024	Erdős Lecturer, Joint Mathematics Meetings
2023	Public Lecturer, Canadian Math Society
2022	Horizons Lecturer, Princeton
2016–18	Dean of Science Fellow, MIT
2017	Forbes 30 Under 30, Science
2012	Student Marshall, Penn State Math
2012	Kermit Anderson Award, Penn State Math
2011	Evan Johnson Memorial Scholarship, Penn State Math

Papers

Ankit Bisain, Alan Edelman, John Urschel. *A New Upper Bound For the Growth Factor in Gaussian Elimination with Complete Pivoting*, arXiv Technical Report, 2023.

Larry Guth, Dominique Maldague, John Urschel. *Estimating Matrix $p \to q$ Norms*, arXiv Technical Report, 2023.

Theo McKenzie, John Urschel. *Nodal Decompositions of a Symmetric Matrix*, arXiv Technical Report, 2023.

John Urschel. *Representing the Special Linear Group with Block Unitriangular Matrices*, PNAS Nexus, Volume 2, Issue 10, 2023

Alan Edelman, John Urschel. *Some New Results on the Maximum Growth Factor in Gaussian Elimination*, SIAM Journal on Matrix Analysis and Applications, to appear.

Enrico Colón, John Urschel. *Hamilton Powers of Eulerian Digraphs*, arXiv Technical Report, 2022.

Jane Breen, Alex Riasanovsky, Michael Tait, John Urschel. *Maximum Spread of Graphs and Bipartite Graphs*, Communications of the American Mathematical Society, 2 (11), 417-480 (2022).

John Urschel, *Graphs, Principal Minors, and Eigenvalue Problems*, PhD Thesis, Massachusetts Institute of Technology, 2021.

Dhruv Rohatgi, John C. Urschel, Jake Wellens. *Regarding Two Conjectures on Clique and Biclique Partitions*, Electronic Journal of Combinatorics, 28(4) (2021).

Erik Demaine, Adam Hesterberg, Frederic Koehler, Jayson Lynch, John Urschel. *Multidimensional Scaling: Approximation and Complexity.*, International Conference on Machine Learning (ICML), 2021.

John C. Urschel, *Uniform Error Estimates for the Lanczos Method*, SIAM Journal on Matrix Analysis and Applications 42.3 (2021): 1423-1450.

John C. Urschel, Jake Wellens. *Testing Gap k-Planarity is NP-Complete*, Information Processing Letters, 169 (2021): 106083.

John C. Urschel, Ludmil T. Zikatanov. *Discrete Trace Theorems and Energy Minimizing Spring Embeddings of Planar Graphs*, Linear Algebra and its Applications, 609 (2021): 73-107.

John C. Urschel. *Nodal Decompositions of Graphs*, Linear Algebra and its Applications, 539 (2018): 60-71.

John C. Urschel. *On the Characterization and Uniqueness of Centroidal Voronoi Tessellations*, SIAM Journal on Numerical Analysis, 55(3), 1525-1547, 2017.

John C. Urschel, Victor-Emmanuel Brunel, Ankur Moitra, Phillipe Rigollet. *Learning Determinantal Point Processes with Moments and Cycles*, International Conference on Machine Learning (ICML), 2017.

Victor-Emmanuel Brunel, Ankur Moitra, Philippe Rigollet, John Urschel. *Rates of Estimation for Determinantal Point Processes*, Conference on Learning Theory (COLT), 2017.

Xiaozhe Hu, John C. Urschel, Ludmil T. Zikatanov. *On the Approximation of Laplacian Eigenvalues in Graph Disaggregation*, Linear and Multilinear Algebra, 65(9): 1805-1822, 2017.

Victor-Emmanuel Brunel, Ankur Moitra, Philippe Rigollet, John C. Urschel. *Maximum Likelihood Estimation of Determinantal Point Processes*, arXiv Technical Report, 2017.

John C. Urschel, Ludmil T. Zikatanov. *On the Maximal Error of Spectral Approximation of Graph Bisection*, Linear and Multilinear Algebra, 64(10): 1972-1979, 2016.

John C. Urschel, Xiaozhe Hu, Jinchao Xu, Ludmil Zikatanov. *A Cascadic Multigrid Algorithm for Computing the Fiedler Vector of Graph Laplacians*, Journal of Computational Mathematics, Vol. 33 No. 2, 2015, 209-226.

John C. Urschel, Ludmil T. Zikatanov. *Spectral Bisection of Graphs and Connectedness*, Linear Algebra and its Applications, Volume 449, 15 May 2014, Pages 1-16.

John Urschel, *Graph-Based Topics in Applied Mathematics*, Master's Thesis, Pennsylvania State University (2013).

John C. Urschel. *A Space-Time Multigrid Method for the Numerical Valuation of Barrier Options*, Communications in Mathematical Finance, vol. 2, no. 3, 2013, 1-20.

John C. Urschel, Joseph R. Galante. *Instabilities in the Sun-Jupiter-Asteroid Three Body Problem*, Celestial Mechanics and Dynamical Astronomy, March 2013, Volume 115, Issue 3, pp 233-259.

Invited Talks

Nodal Counts of Graphs

Combinatorics Seminar, Brown University, November 2023.

Normalizing Flows, the Special Linear Group, and Block Unitriangular Matrices

Machine Learning Seminar, University of Illinois at Urbana-Champaign, September 2023.

Three Years of Computing with Alan

Synergistic Interactions between Theory and Computation, a Conference Celebrating Alan Edelman's Contributions and Impact on his 60th Birthday, July 2023.

From Moments to Matrices

Open Neighborhood Seminar, Harvard Math, September 2022.
SPUR Lecture Series, MIT Math, July 2023.

The Magic of Determinants

Public Lecture, Canadian Mathematics Society Summer Meeting, June 2023.

A Journey into Math

OURFA^{2}M^2 (Online Undergraduate Resource Fair for the Advancement and Alliance of Marginalized Mathematicians) Seminar, November 2022.

Maximizing the Spread of Symmetric Non-Negative Matrices

Computational Mathematics and Applications Seminar, University of Oxford Mathematical Institute, June 2022.
Combinatorics Seminar, Massachusetts Institute of Technology, September 2022.

Matrix Analysis in Action

Causeway Seminar, Department of Mathematics, Northwestern University, August 2022.
Black Heroes of Mathematics Conference, October 2022.

Journeys in Math: A conversation about the joys, struggles, and stories of three generations of mathematicians

Horizons Seminar (with guests Bill Massey & Kimberly Sellers), Department of Mathematics, Princeton University, April 2022.

MathROOTS: Joy Through Challenge and Problem Solving

Navajo Math Circles Summer Teacher Workshop, July 2022.

Determinantal Point Processes, Principal Minor Assignments, and Algebraic Graph Theory

Horizons Lecture, Mathematics Department Colloquium, Princeton University, April 2022.

A Tutorial on Gaussian Elimination

Computer Science/Discrete Mathematics Seminar II, Institute for Advanced Study, April 2022.

Old and New Results on the Spread of the Spectrum of a Graph

Members' Colloquium, Institute for Advanced Study, December 2021.

Learning Determinantal Point Processes

Workshop on Neural Networks, Learning, and Multilevel Finite Element Methods (in honor of Jinchao Xu's 40 years of achievements in mathematical research), Center for Computational Mathematics and its Applications, Penn State University, November 2021.

Gaussian Elimination with Complete Pivoting: Searching for a Needle in a Haystack

Mathematical Conversations, Institute for Advanced Study, October 2021.

An Introduction to Determinantal Point Processes

Computer Science/Discrete Mathematics Seminar II, Institute for Advanced Study, October 2021.

Maximum Spread of Graphs and Bipartite Graphs

Applied Mathematics Colloquium, Princeton University, September 2021.

Graphs, Principal Minors, and Eigenvalue Problems

Short Post-Doctoral Talks, School of Mathematics, Institute for Advanced Study, September 2021.

Topics in Spectral Graph Theory

Causeway Seminar, Department of Mathematics, Northwestern University, August 2021.

Stress Minimization for Low Diameter Graphs

Online Seminar on Mathematical Foundations of Data Science, Penn State University, August 2020.
Workshop on Mathematical Machine Learning and Applications, Center for Computational Mathematics and Applications, Penn State University, December 2020.

Some Results on Force-Directed Drawings of Graphs

Numerical Analysis & Scientific Computing Seminar, Courant Institute of Mathematical Sciences, NYU, October 2020.
Mathematics/Computer Science Seminar, Cornell University, October 2020.
Widely Applied Mathematics Seminar, Harvard University, October 2020.

Estimating Eigenvalues with the Lanczos Method

Computer Science Seminar, University of California, Berkeley, September 2020.
Applied Mathematics Seminar, Massachusetts Institute of Technology, October 2020.

Uniform Error Estimates for the Lanczos Method

Optimization Seminar, Princeton University, August 2020.

Spring Embeddings of Planar Graphs

Graphs & Networks Conference, Tufts University, July 2020.

Iterative Methods for Matrices and Polynomial Optimization Problems

Mathematics Colloquium, Villanova University, February 2020.

Nodal Decompositions of Graphs

Special Session on Recent Trends in Algebraic Graph Theory, AMS Spring Central and Western Joint Sectional Meeting, March 2019.

Randomized Solvers, Recent Advances in Multilevel Solvers Mini-Symposium

SIAM Conference on Computational Science and Engineering, February 2019.

On the Approximation of Laplacian Eigenvalues in Graph Disaggregation

Mathematics Colloquium, University of Washington, March 2017.

Trace Theorems and Drawings of Planar Graphs

Discrete Mathematics Seminar, University of Delaware, March 2017.

Learning Determinantal Point Processes with Moments and Cycles

Computational and Applied Mathematics Colloquium, Penn State University, February 2017.
Center for Applied Mathematics Colloquium, Cornell University, February 2017.
Student Chapter of SIAM Seminar, Tufts University, February 2018.

Existence and Uniqueness of Centroidal Voronoi Tessellations

Scientific Computing Colloquium, Florida State University, July 2016.

Voronoi Tessellations in Today's World

Guterman Lecture, Tufts University, April 2016.

A Cascadic Multigrid Algorithm for Computing the Fiedler Vector of Graph Laplacians

CryptoMathematics Institute Mathfest, National Security Agency, June 2015.

Spectral Bisection of Graphs and Connectedness

Mathematics Colloquium, University of Maryland, April 2015.

Teaching

Massachusetts Institute of Technology

18.330	Fa. 2023	Lecturer, Introduction to Numerical Analysis
18.03	Sp. 2018	Recitation Instructor, Differential Equations (SER 6.9/7)

Pennsylvania State University

Math 232	Fa. 2013	Lecturer, Integral Vector Calculus (SRTE 6.7/7)
Math 041	Sp. 2013	Lecturer, Trigonometry and Analytic Geometry (SRTE 6.6/7)

Service

Referee: American Math Monthly, Annals of Applied Probability, Communications in Mathematical Sciences, Discrete Mathematics, IEEE Signal Processing Letters, Journal of Scientific Computing, Linear and Multilinear Algebra, NeurIPS, SIAM Journal of Matrix Analysis.

Broader Service: Have served on NSF review panels.

Grants

NSF Grant DMS-2218846 "PRIMES Experience: Broadening Math Research and Enrichment Options for High School Students," Co-Principal Investigator

Extracurricular Programs

PRIMES MathROOTS Program, MIT Math *2019-Present*

Role: Academic Coordinator (Mentor in 2019)

MathROOTS is is a two week mathematical talent accelerator summer program hosted by MIT PRIMES for high-potential high school students from underrepresented backgrounds or under-served communities who are interested in exploring creative topics in mathematics and problem solving. As the academic coordinator, I oversee the hiring of academic mentors, the acceptance of prospective students, the academic curriculum and schedule for the program, and the academic lectures. The improvement that these students exhibit over a two week period is startling, and the majority of these students from previous years are now attending MIT or a university of a similar caliber. Being a part of this program is an absolute pleasure.

Undergraduate Research Opportunities Program, MIT *2019-Present*

Role: Research Supervisor

This research program allows undergraduates to work with a graduate student or faculty member to solve some interesting research problem. I have mentored a number of undergraduate students.

Mathical Book Prize, MSRI *2019-Present*

Role: Chair of Selection Committee (Committee Member 2019-2021)

The Mathical Book Prize, awarded by MSRI, is an annual award for fiction and nonfiction books that inspire children of all ages to see math in the world around them. I am a chair of the selection committee, and am more broadly involved in the dissemination of these fantastic books.

National Museum of Mathematics *2016-Present*

Role: Board Member (Advisory Counsel 2016-2017)

The National Museum of Mathematics (MoMath) highlights the role of math in illuminating the patterns and structures all around us. I serve on the board of the museum and am particularly involved in the exhibits and programming of the museum.

Directed Reading Program, MIT Math *2018-2021*
Role: Mentor

This programs pairs undergraduates with a graduate student based on shared interests, and the graduate student assists the undergraduates in reading some advanced text in mathematics during the MIT Independent Activities Period (IAP). I took part in this program while I was a PhD student at MIT. In 2018, I mentored Thuy Duong Vuong, reading *Modern Graph Theory* by Bollobás. In 2019, I mentored Agustin Garcia and Michael Tang, reading *Elements of Information Theory* by Cover and Thomas. In 2020, I mentored Hugo Ramirez and Sonia Reilly, reading *Numerical Analysis* by Kress. Finally, in 2021, I mentored Catherine Ji and Amanda Vanegas Ledesma, reading *Multigrid* by Trottenberg.

Comput. Math for Undergrad. Students Program, PSU Math *2013-2014*
Role: Co-Organizer/Research Supervisor

The Computational Mathematics for Undergraduate Students Program was organized and led by Professor Ludmil Zikatanov and myself, and provided summer research opportunities to undergraduate students at Penn State. In 2013, with undergraduate students Maureen Gallagher, Bradley Thompson, Dana Tobin, and Colleen Tygh, we investigated two research topics: graph drawing using subspace correction methods for eigenvalue computations and the development of monotone discretizations and fast solvers for convection diffusion equations. In 2014, with undergraduate student Laura San Román, we investigated efficient algorithms for planar graph drawings using Tutte spring embeddings. Laura is a former student from my Penn State Math 232 course.

Personal

Married to author/New Yorker staff writer Louisa Thomas. Has two children. Former NFL (American) football player. Recipient of Campbell Trophy (academic Heisman) and Sullivan Award (nation's top amateur athlete). Plays chess (poorly).

References

Available upon request.