Moon Duchin

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Mathematics · STS · Tisch College of Civic Life | Tufts University

Education

University of Chicago   MS 1999, PhD 2005
Mathematics
Advisor: Alex Eskin   Dissertation: *Geodesics track random walks in Teichmüller space*

Harvard University   BA 1998
Mathematics and Women's Studies

Appointments

Tufts University
Professor of Mathematics   2021—
John Dibiaggio Professor of Citizenship and Public Service   2023—
    Assistant Professor, Associate Professor   2011–2021

Principal Investigator │ MGGG Redistricting Lab   2017—

Senior Fellow │ Jonathan M. Tisch College of Civic Life   2017—

Director │ Program in Science, Technology, & Society   2015–2021

University of Michigan
Assistant Professor (postdoctoral)   2008–2011

University of California, Davis
NSF VIGRE Postdoctoral Fellow   2005–2008

Research Interests

Data science for civil rights, elections, computing and law, geometry and redistricting.
Science, technology, and society, science policy, census data, privacy, computational social choice.
Random walks and Markov chains, partition problems, networks, algorithmic fairness.
Geometric group theory, counting and growth, nilpotent groups, dynamics of group actions.
Geometric topology, hyperbolicity, metric geometry, Teichmüller theory.

Selected Awards & Distinctions

Sloan Professor, MSRI Program in Algorithms, Fairness, and Equity   Fall 2023
Seelye Fellow, University of Auckland Department of Mathematics   2023
Radcliffe Fellow - Evelyn Green Davis Fellowship   2018–2019
Guggenheim Fellow   2018
Fellow of the American Mathematical Society   elected 2017
NSF C-ACCEL (PI) - Harnessing the Data Revolution: Network science of Census data   2019–2020
NSF grants (PI) - CAREER grant and continuous grants from Topology/Geometric Analysis   2009–2023
Professor of the Year, Tufts Math Society   2012–2013
AAUW Dissertation Fellowship   2004–2005
NSF Graduate Fellowship   1998–2002
Lawrence and Josephine Graves Prize for Excellence in Teaching (U Chicago)   2002
Robert Fletcher Rogers Prize (Harvard Mathematics)   1995–1996

Political Geometry: Rethinking Redistricting in the U.S. with Math, Law, and Everything In Between
25 chapters, 475 pages. Birkhäuser Books 2022. Preprint online. (eds. Moon Duchin, Olivia Walch)
see: Introduction, Compactness, Communities of Interest, Clustering, Random Walks, Ranked Choice Voting.

Spanning tree methods for sampling graph partitions
Submitted. arXiv:2210.01401 (with Sarah Cannon, Dana Randall, and Parker Rule)

Ranked choice voting and proportional representation
Submitted. Online. (with Gerdus Benade, Ruth Buck, Dara Gold, and Thomas Weighill)

Discrete geometry for electoral geography
Political Geography, *in revision*. arXiv:1808.05860 (with Bridget Eileen Tenner)

Measuring segregation via analysis on graphs
SIAM Journal on Matrix Analysis and Applications (SIMAX), **44** (1) 2023, 80–105. arXiv:2212.10708
(with James Murphy and Thomas Weighill)

Implementing partisan symmetry: Problems and paradoxes
Political Analysis **31** (3) 2023, 305–324. arXiv:2008:06930
(with Daryl DeFord, Natasha Dhamankar, Mackenzie McPike, Gabe Schoenbach, and Ki-Wan Sim)

Redistricting for proportionality
The Forum: A Journal of Applied Research in Contemporary Politics, Vol. 20, No. 3-4, Jan 2023, 371–393. Online.
(with Gabe Schoenbach)

Blind justice: Algorithms and neutrality in the case of redistricting
Proceedings of 2nd ACM Symposium on Computer Science and Law (CS&Law), Nov 2022, 101–108. Online.
(with Doug Spencer)

Aggregating community maps
ACM Conference on Advances in GIS (SIGSPATIAL), Nov 2022, 1–12. Online. (with Erin Chambers, Ranthony Edmonds, Parker Edwards, JN Matthews, Anthony Pizzimenti, Chanel Richardson, Parker Rule, and Ari Stern)

Private numbers in public policy: Census, differential privacy, and redistricting
Harvard Data Science Review, Spec. Iss. 2, June 2022. Online. (with Aloni Cohen, JN Matthews, and Bhushan Suwal)

The (homological) persistence of gerrymandering
Foundations of Data Science, Vol 4, Issue 4 (2022): 581–622. Online. (with Thomas Needham and Thomas Weighill)

Recombination: A family of Markov chains for redistricting
Harvard Data Science Review. Issue 3.1, Winter 2021. Online. (with Daryl DeFord and Justin Solomon)

Census TopDown: The impact of differential privacy on redistricting
2nd Symposium on Foundations of Responsible Computing (FORC 2021), 5:1–5:22. Available online.
(with Aloni Cohen, JN Matthews, and Bhushan Suwal)

Models, Race, and the Law
Yale Law Journal Forum, Vol. 130 (March 2021). Available online. (with Doug Spencer)

Computational Redistricting and the Voting Rights Act
Election Law Journal, Volume 20, Number 4 (2021), 407–441. Available online.
(with Amariah Becker, Dara Gold, and Sam Hirsch)

Clustering propensity: Segregation in networks
Preprint. (with Emilia Alvarez, Everett Meike, and Marshall Mueller; appendix by Tyler Piazza)

Mathematics of nested districts: The case of Alaska
Statistics and Public Policy. Vol 7, No 1 (2020), 39–51. (w/ Sophia Caldera, Daryl DeFord, Sam Gutekunst, & Cara Nix)

A computational approach to measuring vote elasticity and competitiveness
Statistics and Public Policy. Vol 7, No 1 (2020), 69–86. (with Daryl DeFord and Justin Solomon)

Redistricting reform in Virginia: Districting criteria in context
Virginia Policy Review, Volume XII, Issue II, Spring 2019, 120–146. (with Daryl DeFord)

Locating the representational baseline: Republicans in Massachusetts
Election Law Journal, Volume 18, Number 4, 2019, 388–401.
(with Taissa Gladkova, Eugene Henninger-Voss, Ben Klingensmith, Heather Newman, and Hannah Wheelen)

Geometry v. Gerrymandering
The Best Writing on Mathematics 2019, ed. Mircea Pitici. Princeton University Press.
reprinted from Scientific American, November 2018, 48–53.

Gerrymandering metrics: How to measure? What's the baseline?
Bulletin of the American Academy for Arts and Sciences, Vol. LXII, No. 2 (Winter 2018), 54–58.

Rebooting the mathematics of gerrymandering: How can geometry track with our political values?
The Conversation (online magazine), October 2017. (with Peter Levine)

A formula goes to court: Partisan gerrymandering and the efficiency gap
Notices of the American Mathematical Society **64** No. 9 (2017), 1020–1024. (with Mira Bernstein)

International mobility and U.S. mathematics
Notices of the American Mathematical Society **64**, No. 7 (2017), 682–683.

Pure Mathematics Publications & Preprints

Conjugation curvature for Cayley graphs
Journal of Topology and Analysis, Vol 14, Number 02 (2022), 439–459. (with Assaf Bar-Natan and Robert Kropholler)

You can hear the shape of a billiard table: Symbolic dynamics and rigidity for flat surfaces
Commentarii Mathematici Helvetici, Vol 96, Issue 3 (2021), 421–463. Available online.
(with Viveka Erlandsson, Christopher Leininger, and Chandrika Sadanand)

Stars at infinity in Teichmüller space
Geometriae Dedicata, Volume 213, 531–545 (2021). (with Nate Fisher)   arXiv:2004.04321

The Heisenberg group is pan-rational
Advances in Mathematics **346** (2019), 219–263. (with Michael Shapiro)

Random nilpotent groups I
International Mathematics Research Notices, Vol. 2018, Issue 7 (2018), 1921–1953.
(with Matthew Cordes, Yen Duong, Meng-Che Ho, and Ayla Sánchez)

Hyperbolic groups
chapter in *Office Hours with a Geometric Group Theorist*, eds. M.Clay,D.Margalit, Princeton U Press (2017), 177–203.

Counting in groups: Fine asymptotic geometry
Notices of the American Mathematical Society **63**, No. 8 (2016), 871–874.

A sharper threshold for random groups at density one-half
Groups, Geometry, and Dynamics **10**, No. 3 (2016), 985–1005.
(with Katarzyna Jankiewicz, Shelby Kilmer, Samuel Lelièvre, John M. Mackay, and Ayla Sánchez)

Equations in nilpotent groups
Proceedings of the American Mathematical Society **143** (2015), 4723–4731. (with Hao Liang and Michael Shapiro)

Statistical hyperbolicity in Teichmüller space
Geometric and Functional Analysis, Volume 24, Issue 3 (2014), 748–795. (with Howard Masur and Spencer Dowdall)

Fine asymptotic geometry of the Heisenberg group
Indiana University Mathematics Journal 63 No. 3 (2014), 885–916. (with Christopher Mooney)

Pushing fillings in right-angled Artin groups
Journal of the LMS, Vol 87, Issue 3 (2013), 663–688. (with Aaron Abrams, Noel Brady, Pallavi Dani, and Robert Young)

Spheres in the curve complex
In the Tradition of Ahlfors and Bers VI, Contemp. Math. **590** (2013), 1–8. (with Howard Masur and Spencer Dowdall)

The sprawl conjecture for convex bodies
Experimental Mathematics, Volume 22, Issue 2 (2013), 113–122. (with Samuel Lelièvre and Christopher Mooney)

Filling loops at infinity in the mapping class group
Michigan Math. J., Vol 61, Issue 4 (2012), 867–874. (with Aaron Abrams, Noel Brady, Pallavi Dani, and Robert Young)

The geometry of spheres in free abelian groups
Geometriae Dedicata, Volume 161, Issue 1 (2012), 169–187. (with Samuel Lelièvre and Christopher Mooney)

Statistical hyperbolicity in groups
Algebraic and Geometric Topology **12** (2012) 1–18. (with Samuel Lelièvre and Christopher Mooney)

Length spectra and degeneration of flat metrics
Inventiones Mathematicae, Volume 182, Issue 2 (2010), 231–277. (with Christopher Leininger and Kasra Rafi)

Divergence of geodesics in Teichmüller space and the mapping class group
Geometric and Functional Analysis, Volume 19, Issue 3 (2009), 722–742. (with Kasra Rafi)

Curvature, stretchiness, and dynamics
In the Tradition of Ahlfors and Bers IV, Contemp. Math. **432** (2007), 19–30.

Geodesics track random walks in Teichmüller space
PhD Dissertation, University of Chicago 2005.

Teaching

Courses Developed or Customized

Mathematics of Social Choice | sites.tufts.edu/socialchoice
Voting theory, impossibility theorems, redistricting, theory of representative democracy, metrics of fairness.
Have designed and taught variants at entry level and at math-major level.

History of Mathematics | sites.tufts.edu/histmath
Social history of mathematics, organized around episodes from antiquity to present. Themes include materials and technologies of creation and dissemination, axioms, authority, credibility, and professionalization. In-depth treatment of mathematical content from numeration to cardinal arithmetic to Galois theory.

Reading Lab: Mathematical Models in Social Context | sites.tufts.edu/models
One hr/wk discussion seminar of short but close reading on topics in mathematical modeling, including history of psychometrics; algorithmic bias; philosophy of statistics; problems of model explanation and interpretation.

Reading Lab: Classification | sites.tufts.edu/classification
One hr/wk discussion seminar of short but close reading on topics in classifications and taxonomies, including censuses; race and ethnicity; academic disciplines, mathematical and legal definition; chemical elements; species and model organisms; sex and gender.

Geometric Literacy
Module-based graduate topics course. Modules have included: p-adic numbers, hyperbolic geometry, nilpotent geometry, Lie groups, convex geometry and analysis, the complex of curves, ergodic theory, the Gauss circle problem.

Markov Chains (graduate topics course)
Teichmüller Theory (graduate topics course)
Fuchsian Groups (graduate topics course)
Continued Fractions and Geometric Coding (undergraduate topics course)
Mathematics for Elementary School Teachers (inquiry-based course for pre-service teachers)

Standard Courses

Mathematical Modeling and Computation (with Python), Discrete Mathematics, Calculus I-II-III, Intro to Proofs, Linear Algebra, Complex Analysis, Differential Geometry, Abstract Algebra, Graduate Real Analysis

Plenary Lecture   June 2023
Symposium on Computational Geometry (SoCG), Dallas, TX

Distinguished Plenary Lecture   June 2021
75th Anniversary Meeting of Canadian Mathematical Society, Ottawa, Ontario   *online (COVID)*

BMC/BAMC Public Lecture   April 2021
Joint British Mathematics/Applied Mathematics Colloquium, Glasgow, Scotland   *online (COVID)*

AMS Einstein Public Lecture in Mathematics   April 2020
Eastern Sectional Meeting of the AMS, Charlottesville, VA   *postponed (COVID)*

Gerald and Judith Porter Public Lecture   January 2018
AMS-MAA-SIAM, Joint Mathematics Meetings, San Diego, CA

Mathematical Association of America Distinguished Lecture   October 2016
MAA Carriage House, Washington, DC

American Mathematical Society Invited Address   September 2016
AMS Eastern Sectional Meeting, Brunswick, ME

Named University Lectures

- Seelye Public Lecture │ University of Auckland, New Zealand	March 2023
- Lorne Campbell Lecture │ Queen's University, Ontario	December 2022
- Plancherel Lecture │ Université de Fribourg, Switzerland	October 2022
- Loeb Lectures in Mathematics │ Washington University in St. Louis	April 2022
- Mathematics and Natural Sciences Divisional Lecture │ Reed College	March 2022
- Parsons Lecture │ UNC Asheville	October 2020
- Math, Stats, CS, and Society │ Macalester College	October 2019
- MRC Public Lecture │ Stanford University	May 2019
- Freedman Memorial Colloquium │ Boston University	March 2019
- Julian Clancy Frazier Colloquium Lecture │ U.S. Naval Academy	January 2019
- Barnett Lecture │ University of Cincinnati	October 2018
- School of Science Colloquium Series │ The College of New Jersey	March 2018
- Kieval Lecture │ Cornell University	February 2018
- G. Milton Wing Lectures │ University of Rochester	October 2017
- Norman Johnson Lecture │ Wheaton College	September 2017
- Dan E. Christie Lecture │ Bowdoin College	September 2017

Math/Computer Science Department Colloquia

- Northeastern University	Feb 2023	- Univ of Illinois - Chicago	Oct 2019
- University of Michigan	Sept 2022	- UC Berkeley	Sept 2018
- UC Berkeley	Apr 2022	- Brandeis-Harvard-MIT-NEU	Mar 2018
- Reed College	Dec 2020	- Northwestern University	Oct 2017
- Georgetown (CS)	Sept 2020	- University of Illinois	Sept 2017
- Santa Fe Institute	July 2020	- University of Utah	Aug 2017

Minicourses

- Modeling democracy (three hours) │ Modern Math Workshop, Puerto Rico	October 2022
- Integer programming and combinatorial optimization (two talks) │ Georgia Tech	May 2021

Visiting Lectures

- Optimized Democracy | Harvard (CS) — Spring 2021, 2022, 2023
- Law of Democracy | Stanford Law School — Fall 2022
- A Democracy Initiative | Harvard Law School — Fall 2022
- Election Law | Yale Law School | Harvard Law School — Spring 2022
- Privacy, Policy, and the U.S. Census | University of Chicago (CS) — Spring 2022

Data Science, Computer Science, Quantitative Social Science

- Online Social Choice and Welfare Seminar — August 2023
- Data Matters Public Lecture | Data Science Institute, Brown University — April 2023
- Computational Social Choice Seminar | Center for Mathematical Social Science, Auckland — March 2023
- Societal Considerations and Applications | Simons Institute for the Theory of Computing — November 2022
- ACM Symposium on Computer Science and Law | Washington, DC — November 2022
- Econ/CS Seminar | Harvard — October 2022
- Can Algorithms Bend the Arc Towards Fairness? | Algorithmic Justice Project, UNM/SFI — March 2022
- Data Linkage Seminar | Massive Data Institute, McCourt School of Public Policy — August 2021
- Mechanism Design for Social Good (MD4SG) Colloquium | MD4SG Initiative — November 2020
- Data Science for Social Good (DS4SG) Workshop | Georgia Tech — November 2020
- Women in Data Science Conference | Microsoft Research New England — March 2020
- Quantitative Research Methods Workshop | Yale Center for the Study of American Politics — February 2020
- Societal Concerns in Algorithms and Data Analysis | Weizmann Institute — December 2018
- Quantitative Collaborative | University of Virginia — March 2018
- Quantitative Social Science | Dartmouth College — September 2017
- Data for Black Lives Conference | MIT — November 2017

Law, Democracy, Political Science, Geography, Studies of Race and Gender

- Data and Democracy Scholar Talk | Harris School, University of Chicago — April 2023
- Voting Rights Panel | Rothgerber Conference, University of Colorado Law School — April 2023
- Censuses and Racial Classification | COMPASS, University of Auckland — March 2023
- The Long 19th Amendment: Women, Voting, and American Democracy | Radcliffe Institute — Nov–Dec 2020
- "The New Math" for Civil Rights | Social Justice Speaker Series, Davidson College — November 2020
- Math, Law, and Racial Fairness | Justice Speaker Series, University of South Carolina — November 2020
- Voting Rights Conference | Northeastern Public Interest Law Program — September 2020
- Political Analysis Workshop | Indiana University — November 2019
- Program in Public Law Panel | Duke Law School — October 2019
- Redistricting 2021 Seminar | University of Chicago Institute of Politics — May 2019
- Geography of Redistricting Conference Keynote | Harvard Center for Geographic Analysis — May 2019
- Political Analytics Conference | Harvard University — November 2018
- Cyber Security, Law, and Society Alliance | Boston University — September 2018
- Clough Center for the Study of Constitutional Democracy | Boston College — November 2017
- Tech/Law Colloquium Series | Cornell Tech — November 2017
- Constitution Day Lecture | Rockefeller Center for Public Policy, Dartmouth College — September 2017

Science, Technology, and Society

- The Mathematics of Accountability | Sawyer Seminar, Anthropology, Johns Hopkins — February 2020
- STS Circle | Harvard Kennedy School of Government — September 2019
- Data, Classification, and Everyday Life Symposium | Rutgers Center for Cultural Analysis — January 2019
- Science Studies Colloquium | UC San Diego — January 2019
- Arthur Miller Lecture on Science and Ethics | MIT Program in Science, Tech, and Society — November 2018

Program Development

Principal Investigator MGGG Redistricting Lab   mggg.org

Multidisciplinary research lab with postdocs, research staff, and undergraduate researchers drawn from mathematics, computer science, software development, geography, policy. Hosts law student externs. Provided public mapping support for roughly 140 localities after 2020 Census data released.

Support includes NSF, Sloan Foundation, Thornburg Foundation, Arnold Foundation, Democracy Fund.

Co-Founder, Program Director Science, Technology, and Society Program   sts.tufts.edu

Interdisciplinary program offering a major and minor, with ∼40 affiliated faculty. Runs popular weekly lunch seminar, Reading Labs on topics from Automation to Classification to Life to Energy.

Organizer

Semester Program in *Algorithms, Fairness, and Equity*, Fall 2023
Mathematical Sciences Research Institute, Berkeley CA

Program will host ∼50 research members on topics connected to mechanism design, fair partitioning, and fair ML.

Short workshops and training programs

- GeoData Bootcamp 2020 (2 weeks, 20 students from around the country)
- Mapping Training 2020 (1 week, 30 students from around the country)
- Graphs and Networks Workshop 2020 (1 day, 500 live participants)
- Data for Election Administration 2019, 2021 (multi-day, dozens of administrators and scholars)

Program Building Research and mentorship programs

- Voting Rights Data Institute 2018, 2019
  Six-week summer research programs hosting 52 and 33 undergraduate and graduate students, respectively, with dozens of visitors from math, CS, law, political science, geography, urban planning, and more.
- Polygonal Billiards Research Cluster 2017, Random Groups Research Cluster 2014
  Five-week intensive summer research programs for vertically integrated groups of 12-14 undergraduate, graduate, postdoctoral, and junior faculty researchers, combining experimental and theoretical work.
- Directed Reading Program and DRP Network   sites.google.com/view/drp-network/
  Co-founded highly successful near-peer mentoring program in 2003 at UChicago. Now exists at >40 math departments as grad-student-run reading program with excellent outcomes for broadening participation in mathematics. Secured NSF grant to expand the program to more campuses and to fund social science research on outcomes.

Graduate Advising in Mathematics

Nate Fisher (PhD 2021),   Sunrose Shrestha (PhD 2020),   Ayla Sánchez (PhD 2017),
Kevin Buckles (PhD 2015),   Mai Mansouri (MS 2014)

Outside committee member for Chris Coscia (PhD 2020), Dartmouth College

Postdoctoral Advising in Mathematics

Principal supervisor Thomas Weighill (2019–2020)

Co-supervisor Daryl DeFord (MIT 2018–2020), Rob Kropholler (2017–2020), Hao Liang (2013–2016)

Program committees and editorial boards

ACM Conference on Fairness, Accountability, and Computing (FAccT)	2022
Symposium on Foundations of Responsible Computing (FORC)	2021
Harvard Data Science Review	since 2019
Advances in Mathematics	since 2018

Committee on Science Policy — 2020–2022
American Mathematical Society

Amicus Brief of Mathematicians, Law Professors, and Students — 2019
principal co-authors: Guy-Uriel Charles and Moon Duchin

Supreme Court of the United States, in Rucho v. Common Cause - cited in dissent

Expert work for redistricting litigation — 2018—
reports, deposition, and/or trial testimony

Wisconsin, North Carolina, Alabama, Pennsylvania, South Carolina, Texas, Georgia

Johnson v. Wis. Elections Comm'n, No. 2021AP1450-OA, 2022 WL 621082 (Wis. Mar. 3, 2022); *NC League of Conservation Voters, et al. v. Hall, et al.* No. 21-cvs-500085 (Wake Cnty. Sup. Ct. 2021); *Milligan, et al. v. Merrill, et al.*, Case No. 2:21-cv-01530-AMM and *Thomas, et al. v. Merrill, et al.*, Case No. 2:21-cv-01531-AMM (N.D. Ala. 2021); *Carter v. Chapman*, No. 7 MM 2022, 2022 WL 702894 (Pa. Mar. 9, 2022); *SC NAACP et al. v. Alexander, et al.*, Case No. 3-21-cv-03302-MBS-TJH-RMG (D.S.C.) (three-judge ct.); *TX NAACP et al. v. Abbott*, Case No. 1:21-CV-00943-RP-JES-JVB.

Presenter on Public Mapping, Statistical Modeling — 2019, 2020
National Conference of State Legislatures

Committee on The Future of Voting: Accessible, Reliable, Verifiable Technology — 2017–2018
National Academies of Science, Engineering, and Medicine

Committee on the Human Rights of Mathematicians — 2016–2019
American Mathematical Society