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—
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, computation and governance, elections, geometry and redistricting.
Science, technology, and society, science policy, census data, technology and law, algorithmic fairness.
Random walks and Markov chains, random groups, random constructions in geometry.
Large-scale geometry, metric geometry, isoperimetric inequalities.
Geometric group theory, growth of groups, nilpotent groups, dynamics of group actions.
Geometric topology, hyperbolicity, Teichmüller theory.

Awards & Distinctions

Research Professor - MSRI Program in Analysis and Geometry of Random Spaces	Spring 2022
Guggenheim Fellow	2018
Radcliffe Fellow - Evelyn Green Davis Fellowship	2018–2019
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 three standard Topology grants	2009–2022
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. Preprint online. Birkhäuser Books, to appear 2022. (eds. Moon Duchin, Olivia Walch)
see: Introduction, Compactness, Communities of Interest, Clustering, Random Walks, Ranked Choice Voting.

Private numbers in public policy: Census, differential privacy, and redistricting
Harvard Data Science Review, to appear 2022. (with Aloni Cohen, JN Matthews, and Bhushan Suwal)

The (homological) persistence of gerrymandering
Foundations of Data Science, to appear 2022. Online first. (with Thomas Needham and Thomas Weighill)

Implementing partisan symmetry: Problems and paradoxes
Political Analysis, to appear 2022. arXiv:2008:06930
(with Daryl DeFord, Natasha Dhamankar, Mackenzie McPike, Gabe Schoenbach, and Ki-Wan Sim)

Measuring segregation via analysis on graphs
Preprint. arXiv:2212.10708 (with James Murphy and Thomas Weighill)

A reversible recombination chain for graph partitions
Preprint. (with Sarah Cannon, Dana Randall, and Parker Rule)

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

Clustering propensity: A mathematical framework for measuring segregation
Preprint. (with Emilia Alvarez, Everett Meike, and Marshall Mueller; appendix by Tyler Piazza)

Discrete geometry for electoral geography
Preprint. (with Bridget Eileen Tenner)   arXiv:1808.05860

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)

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)

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)

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

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, to appear 2022. Online first. (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

Weekly Seminars Organized
- Geometric Group Theory and Topology
- Science, Technology, and Society Lunch Seminar

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   [March 2020]
Southeastern Sectional Meeting of the AMS, Charlottesville, VA   *postponed*

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

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

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

Named University Lectures

- 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

- Reed College	Dec 2020		- Université de Neuchâtel	Jun 2016
- Georgetown (CS)	Sept 2020		- Brandeis University	Mar 2016
- Santa Fe Institute	July 2020		- Swarthmore College	Oct 2015
- UC Berkeley	Sept 2018		- Bowling Green	May 2015
- Brandeis-Harvard-MIT-NEU	Mar 2018		- City College of New York	Feb 2015
- Northwestern University	Oct 2017		- Indiana University	Nov 2014
- University of Illinois	Sept 2017		- the Technion	Oct 2014
- University of Utah	Aug 2017		- Wisconsin–Madison	Sept 2014
- Wesleyan	Dec 2016		- Stony Brook	March 2013
- Worcester Polytechnic Inst.	Dec 2016			

Visiting Lectures

- Election Law, Yale Law School, Spring 2022

- Election Law, Harvard Law School, Spring 2022

- Privacy, Policy, and the U.S. Census, University of Chicago, Spring 2022

Minicourses

- Integer programming and combinatorial optimization (two talks) | Georgia Tech   May 2021
- Workshop in geometric topology (main speaker, three talks) | Provo, UT   June 2017
- Growth in groups (two talks) | MSRI, Berkeley, CA   August 2016
- Hyperbolicity in Teichmüller space (three talks) | Université de Grenoble   May 2016
- Counting and growth (four talks) | IAS Women's Program, Princeton   May 2016
- Nilpotent groups (three talks) | Seoul National University   October 2014
- Sub-Finsler geometry of nilpotent groups (five talks) | Galatasaray Univ., Istanbul   April 2014

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

Data Science, Computer Science, Quantitative Social Science

- 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
- Privacy Tools Project Retreat | Harvard   May 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

Political Science, Geography, Law, Democracy, Fairness

- 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

Selected Professional Service and Public-Facing Work

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

Pennsylvania, North Carolina, Wisconsin, South Carolina, Alabama

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

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)

Selected Visiting Positions and Residential Fellowships

Visiting Professor   Department of Mathematics   Fall 2021
Boston College | Chestnut Hill, MA

Fellow   Radcliffe Institute for Advanced Study   2018–19
Harvard University | Cambridge, MA

Member   Center of Mathematical Sciences and Applications   2018–19
Harvard University | Cambridge, MA

Visitor   Microsoft Research   2018–19
MSR New England | Cambridge, MA