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
Associate Professor 2015—
Assistant Professor 2011–2015

Director | Program in Science, Technology, & Society 2015—
(on leave 2018–2019)

Principal Investigator | Metric Geometry and Gerrymandering Group (Research Lab) 2017—

Senior Fellow | Tisch College of Civic Life 2017—

University of Michigan
Assistant Professor (postdoctoral) 2008–2011

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

Research Interests

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.
Data science for civil rights, computation and governance, elections, geometry and redistricting.
Science, technology, and society, science policy, technology and law, social epistemology.

Awards & Distinctions

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

Publications & Preprints

You can hear the shape of a billiard table: Symbolic dynamics and rigidity for flat surfaces
Submitted. (with Viveka Erlandsson, Christopher Leininger, and Chandrika Sadanand) arXiv:1804.05690

The (homological) persistence of gerrymandering
Submitted. (with Thomas Needham and Thomas Weighill) arXiv:2007.02390

Recombination: A family of Markov chains for redistricting
Submitted. (with Daryl DeFord and Justin Solomon) mggg.org/ReCom

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

Noising the Census: Differentially private algorithms for disclosure avoidance
Preprint. (with Aloni Cohen, JN Matthews, Bhushan Suwal, and Peter Wayner)

Stars at infinity in Teichmüller space
Geometriae Dedicata, to appear. (with Nate Fisher) arXiv:2004.04321

Conjugation curvature for Cayley graphs
Journal of Topology and Analysis, to appear. (with Assaf Bar-Natan and Robert Kropholler) arXiv:1712.02484

Random walks and redistricting: New applications of Markov chain Monte Carlo
In press. (with Daryl DeFord) For edited volume, Political Geometry. Under contract with Birkhäuser.

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

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

Random nilpotent groups I
IMRN, 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. Matt Clay and Dan Margalit,
Princeton University 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.

Science, Technology, Law, and Policy Publications & Preprints

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

Implementing partisan symmetry: Problems and paradoxes
Submitted. (with Daryl DeFord, Natasha Dhamankar, Mackenzie McPike, Gabe Schoenbach, and Ki-Wan Sim)

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

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.

Graduate Advising in Mathematics

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

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

Postdoctoral Advising in Mathematics

Principal supervisor Thomas Weighill (2019—)

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

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.

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.

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

Standard Courses

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

Selected Talks and Lectures

Distinguished Plenary Lecture [June 2020]
75th Anniversary Meeting of Canadian Mathematical Society, Ottawa, Ontario *postponed*

BMC/BAMC Public Lecture [April 2020]
Joint British Mathematics/Applied Mathematics Colloquium, Glasgow, Scotland *postponed*

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

- Parsons Lecture | UNC Asheville — October 2020
- Loeb Lectures in Mathematics | Washington University in St. Louis — [March 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

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

Minicourses

- 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 Science for Social Good Workshop (DS4SG) | Georgia Tech — November 2020
- Privacy Tools Project Retreat | Harvard (virtual) — 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

- The Long 19th Amendment: Women, Voting, and American Democracy | Radcliffe Institute — Fall 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
- Midwest Redistricting Seminar | National Conference of State Legislatures, Columbus, OH — 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

Editorial Boards

Harvard Data Science Review
Associate Editor — since 2019

Advances in Mathematics
Member, Editorial Board — since 2018

Selected Professional and Public Service

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

Consulting Expert for Governor Tom Wolf 2018
Pennsylvania Congressional Redistricting (PA State Supreme Court)

Committee on Science Policy 2020–2023
American Mathematical Society

Program Committee 2020–2021
Symposium on Foundations of Responsible Computing

Presenter on Public Mapping, Statistical Modeling 2019, 2020
National Conference of State Legislatures, Regional Redistricting Conferences

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

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

Visiting Positions and Residential Fellowships

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 Lab 2018–19
MSR New England | Cambridge, MA

Research Member Geometric Group Theory program Fall 2016
Mathematical Sciences Research Institute | Berkeley, CA

Research Member Random Walks and Asymptotic Geometry of Groups program Spring 2014
Institut Henri Poincaré | Paris, France

Research Member Low-dimensional Topology, Geometry, and Dynamics program Fall 2013
Institute for Computational and Experimental Research in Mathematics | Providence, RI

Research Member Geometric and Analytic Aspects of Group Theory program May 2012
Institut Mittag-Leffler | Stockholm, Sweden

Research Member Quantitative Geometry program Fall 2011
Mathematical Sciences Research Institute | Berkeley, CA

Postdoctoral Fellow Teichmüller "project blanc" Spring 2009
Agence Nationale de la Recherche (Collège de France) | Paris, France

Program Development, Mentoring, Professional Development

Voting Rights Data Institute Summer 2018, 2019

Developed and ran six-week summer data intensive at Tufts/MIT for over 30 graduate and undergraduate students from a range of disciplines, including mathematics, computer science, geography, philosophy, political science, and law.
Supervised software development, data collection and preparation, and innovative research projects.

Mentoring Workshop for Graduate Advisors in Mathematics since 2015

Designed workshop for junior faculty in mathematics on best practices in advising doctoral students, featuring research in social psychology on mentorship across race, sex, class, and other social difference.
Held at Tufts in April 2015, cloned at Michigan in May 2017, and Ohio State in Spring 2019.

Directed Reading Program since 2003
Directed Reading Program Network since 2017

Co-founded program at U Chicago pairing math majors with grad student mentors for reading projects.
Co-founded national network linking Directed Reading Programs in a range of math departments around the country to facilitate best practices for mentorship.
This highly impactful mentoring program has been cloned by its alumni at 15+ institutions. Now serving on five-person faculty oversight team for NSF-funded network project.

Research Cluster in Polygonal Billiards Summer 2017
Research Cluster in Random Groups Summer 2014

Ran six-week programs for mix of undergrads, grads, and faculty, mixing experimental and research projects.
Hosted at Tufts University, funded by NSF CAREER grant.

Undergraduate Faculty Program in Geometric Group Theory Summer 2012

Directed three-week "Research Lab" with 16 participating faculty members from undergraduate institutions.
Park City Math Institute, funded by NSF and IAS.

Research Experience for Undergraduates (REU) on Metric Geometry Summer 2006

Designed and ran month-long program supervising seven undergraduates and three grad students.
Hosted at UC Davis, funded by NSF VIGRE grant.

Warmup Program/"WOMP" since 2001

Co-founded program at U Chicago preparing new graduate students for the doctoral program.

Recent Conferences, Workshops, Trainings Organized

- **Graphs and Networks Workshop** | Virtual conference with 500 attendees | August 2020
- **Geodata Bootcamp** and **Mapping Training** | Virtual trainings for students | June–July 2020
- **Border Science: Data, Technology, and Meaning at Political Boundaries** | Exploratory workshop
  February 2020 at Radcliffe Institute for Advanced Study
- **Redistricting in 2020** | Session of Harvard Data Science Symposium | October 2019
- **Geometry of Redistricting Conferences** | Large public conferences attracting over 1200 attendees collectively
  Somerville MA 2017, Madison WI 2017, Durham NC 2017, Austin TX 2018, San Francisco CA 2018
- **Expert Witness Training Sessions** | most recent December 2018 at Radcliffe
- **Educator Workshops** | most recent July 2019 at Tufts
- **Hackathons** | most recent March 2018 at USF
- **Mapmaking Training** | February 2018 at UT Austin