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

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

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; Finer coarse geometry; Metric geometry of groups and surfaces	2009–2019
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

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

Discrete Ricci curvature for Cayley graphs
Submitted. (with Assaf Bar-Natan and Robert Kropholler)   arXiv:1712.02484

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

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, to appear December 2019.
(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.

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

A Computational Approach to Measuring Vote Elasticity and Competitiveness
Submitted. (with Daryl DeFord and Justin Solomon)   mggg.org/Competitiveness

Mathematics of Nested Districts: The Case of Alaska
Submitted. (with Sophia Caldera, Daryl DeFord, Sam Gutekunst, and Cara Nix)   mggg.org/Alaska

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

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

Clustering propensity: A mathematical framework for measuring segregation
In preparation. (with Emilia Alvarez, Everett Meike, Marshall Mueller, and Tyler Piazza)

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

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.

White Papers & Reports

Findings on the City of Lowell's Election Systems
White paper, Oct 2019. (with Ruth Buck, Dara Gold, and JN Matthews)   mggg.org/Lowell-Detailed-Report

Study of reform proposals for the Chicago City Council
White paper, Apr 2019. (with Hakeem Angulu, Ruth Buck, Daryl DeFord, Howard Fain, Max Hully, Maira Khan, Zach Schutzman, and Oliver York)   mggg.org/Chicago.pdf

Comparison of districting plans for the Virginia House of Delegates
White paper, Nov 2018. (with Daryl DeFord and Justin Solomon)   mggg.org/VA-report.pdf

Study of voting systems for Santa Clara, CA
White paper, Feb 2018. (with Mira Bernstein, Tommy Ratliff, and Stephanie Somersille)   mggg.org/SantaClara.pdf

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.

Teichmüller Theory (graduate topics course)
Fuchsian Groups (graduate topics course)
Continued Fractions and Geometric Coding (undergraduate topics course)
Mathematics for Elementary School Teachers
Feminist Science Studies (syllabus only, developed for Women's Studies at Michigan)
Problems in Gender Studies (co-taught at University of Chicago)

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

Recent Conferences, Workshops, Trainings

- **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

Graduate Advising in Mathematics

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

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

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

Editorial Boards

Harvard Data Science Review
Associate Editor   since 2019

Advances in Mathematics
Member, Editorial Board   since 2018

Selected Talks and Lectures

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

BMC/BAMC Public Lecture
Joint British Mathematics/Applied Mathematics Colloquium, Glasgow, Scotland   April 2020

AMS Einstein Public Lecture in Mathematics
Southeastern Sectional Meeting of the AMS, Charlottesville, VA   March 2020

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

Science, Technology, and Society

- 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 and Quantitative Social Science

- 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   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

Named University Lectures

- Parsons Lecture | UNC Asheville   April 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

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

Mathematics Department Colloquia

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

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.

Visiting Positions

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