DANIEL IRVING BERNSTEIN

https://dibernstein.github.io

dibernst@mit.edu ⋄ bernstein.daniel@gmail.com

Research keywords: Applied algebraic geometry, convex and discrete geometry, tropical geometry, matrix completion, rigidity theory, matroids, algebraic statistics, machine learning theory, causal inference, phylogenetics, contingency tables

EDUCATION AND EMPLOYMENT

2021		Jerrold E. Mardsen Postdoc, Fields Institute
2020		Research Associate, Duke University
2018 – 2020		NSF Postdoc, Massachusetts Institute of Technology (Mentor: Caroline Uhler)
2018		ICERM Postdoc, Brown University
2018	Ph.D.	North Carolina State University, Mathematics (advisor: Seth Sullivant)
2015	M.S.	North Carolina State University, Mathematics
2013	B.S.	Davidson College, Mathematics (departmental honors, *magna cum laude*)

HONORS AND AWARDS

2021	Jerrold E. Marsden Postdoctoral Fellowship ($35,000 CAD)
2018	NSF Mathematical Sciences Postdoctoral Research Fellowship ($150,000 USD)
2018	NC State Math Department Winton-Rose Award ($1,000 USD)
2013	North Carolina State University Graduate Fellowship ($4,000 USD)
2013	William G. McGavock Mathematics Award (Davidson College Math Department)
2013	Patterson Prize for talk given at the MAA Southeastern Section Spring Meeting

PAPERS

Submitted papers and preprints

15. Generic symmetry-forced infinitesimal rigidity: translations and rotations. Submitted. arXiv:2003.10529.
14. On Alignment in Deep Linear Neural Networks (with Adityanarayanan Radhakrishnan, Eshaan Nichani, and Caroline Uhler). Submitted. arXiv:2003.06340
13. Typical ranks in symmetric matrix completion (with Greg Blekherman and Kisun Lee). Submitted. arXiv:1909.06593

Journal Papers

12. The algebraic matroid of the funtf variety (with Cameron Farnsworth and Jose Israel Rodriguez). *Journal of Pure and Applied Algebra*, Volume 224, Issue 8, August 2020. arXiv:1812.10353
11. L-infinity optimization to Bergman fans of matroids with an application to phylogenetics. *SIAM Journal on Discrete Mathematics*, 34, no. 1 (2020): 701-720. arXiv:1702.05141
10. The tropical Cayley-Menger variety (with Robert Krone). *SIAM Journal on Discrete Mathematics*, **33** (2019) no.3, pp. 1725–1742. arXiv:1812.09370
9. Typical and Generic Ranks in Matrix Completion (with Greg Blekherman and Rainer Sinn). *Linear algebra and its applications*, Volume 585, 15 January 2020, pp. 71-104. arXiv:1802.09513
8. Unimodular hierarchical models and their Graver bases (with Christopher O'Neill). *Journal of Algebraic Statistics.* **8** (2017) no. 2. https://doi.org/10.18409/jas.v8i2.66. arXiv:1704.09018
7. Completion of tree metrics and rank 2 matrices. *Linear Algebra and its Applications.* **533** (2017), pp. 1-13. arXiv:1612.06797

6. L-infinity optimization to linear spaces and phylogenetic trees (with Colby Long). *SIAM Journal on Discrete Mathematics.* **31** (2017) no. 2, pp. 875-889. arXiv:1702.05127

5. Unimodular binary hierarchical models (with Seth Sullivant). *Journal of Combinatorial Theory, Series B.* **123** (2017), pp. 97-125. arXiv:1502.06131

4. Normal binary hierarchical models (with Seth Sullivant). *Experimental Mathematics.* **26** (2017) no. 2 pp. 153-164. arXiv:1508.05461

3. Bounds on the expected size of the maximum agreement subtree (with Lam Si Tung Ho, Colby Long, Mike Steel, Katherine St. John and Seth Sullivant). *SIAM Journal on Discrete Mathematics.* **29** (2015) no. 4, pp. 2065-2074. arXiv:1411.7338

2. On three sets with nondecreasing diameter (with Carl Yerger and David J. Grynkiewicz). *Discrete Mathematics.* **338** (2015) no. 8, pp. 1328-1344. arXiv:1407.5122

Refereed conference proceedings

1. Ordering-based causal structure learning in the presence of latent variables (with Basil Saeed, Chandler Squires, and Caroline Uhler). *The 23rd International Conference on Artificial Intelligence and Statistics (AISTATS 2020).* arXiv:1910.09014

TALKS

Invited conference talks

25. Rigidity of symmetry-forced frameworks. Would have been between June 22-26. Algebraic Statistics 2020 at University of Hawai'i at Manoa. Canceled due to the COVID-19 pandemic, became a contributed online talk.

24. Title not determined. Would have been between June 15-17. FOCM workshop in computational algebraic geometry at Simon Frasier University. Canceled due to the COVID-19 pandemic.

23. *The tropical Cayley-Menger variety.* April 4, 2020. Special Session on Rigidity Theory, Distance Geometry and Applications. AMS Spring Central Sectional Meeting at Purdue University. Canceled due to COVID-19 pandemic. Would have been between March 15-21.

22. *The algebraic matroid of a Hadamard product of linear spaces.* Would have been between March 15-21 at the Oberwolfach workshop, *Algebraic structures in statistical methodology.* Canceled due to COVID-19 pandemic.

21. *Tropical geometry in rigidity theory.* January 13, 2020. Discrete structures, a Heilbronn focused research group. Lancaster University, UK.

20. *The tropical Cayley-Menger variety.* July 17, 2019. Algebra meets combinatorics in Neuchatel. University of Neuchatel, Switzerland.

19. **The tropical Cayley-Menger variety.* July 9, 2019. SIAM Conference on Applied Algebraic Geometry, minisymposium on algebraic geometry of low-rank matrix completion. Bern, Switzerland (*self-invite, I spoke at the session I organized).

18. *Nonlinear algebra and matrix completion.* November 16, 2018. Nonlinear algebra in applications workshop at Brown University, ICERM.

17. *Using tropical geometry to characterize the algebraic matroid for rank-2 matrix completion.* July 13, 2018. SIAM Annual Meeting, minisymposium on distance geometry. Portland, OR.

16. *Typical and generic ranks in low-rank matrix completion.* April 21, 2018. AMS Spring Eastern Sectional Meeting at Northeastern University. Special Session on Algebraic Statistics.

15. *Tropical linear spaces in phylogenetics.* September 23, 2017. AMS Fall Southeastern Sectional Meeting at University of Central Florida. Special Session on Mathematics of Biomolecules: Discrete, Algebraic, and Topological.

14. *Tropical Geometry for Rigidity Theory and Matrix Completion.* August 1, 2017. SIAM Conference on Applied Algebraic Geometry, minisymposium on algebraic methods in rigidity theory. Atlanta, Georgia

13. *Tropical linear spaces in phylogenetics.* May 27, 2017. Interactions between algebra and the sciences. Max Planck Institute for Mathematics in the Sciences. Leipzig, Germany

12. *Combinatorial properties of hierarchical models.* July 11, 2016. SIAM Annual Meeting, minisymposium on algebraic statistics

11. *Toric Varieties in Statistics.* April 9, 2016. Meeting on Algebraic Geometry for Applications. Clemson University. Clemson, SC.

10. *Hierarchical Models: Normality and Related Properties.* Oct 3, 2015. 2015 AMS fall central sectional meeting, special session on algebraic statistics and its interactions with combinatorics, computation, and network science. Loyola University. Chicago, IL.

Seminar talks and guest lectures

9. Virtual seminar on algebraic matroids and rigidity theory (July 16, 2020)

8. Virtual seminar on algebraic matroids and rigidity theory (March 26, 2020)

7. Valley geometry seminar at UMass Amherst (October 25, 2019)

6. Discrete math seminar at Texas State University (May 3, 2019)

5. Guest lecture in Ngoc Tran's tropical geometry class at UT Austin (May 2, 2019)

4. Applied algebra and geometry seminar at Massachusetts Institute of Technology (Nov 21, 2017)

3. Algebra, geometry, and combinatorics seminar at San Francisco State University (Oct 19, 2016)

2. Combinatorics, algebra, convexity, algorithms and optimization seminar at UC Davis (Oct 17, 2016)

1. Graduate student algebra seminar at NC State, about once each semester while in grad school

EVENT ORGANIZING

7. Organizer of the Virtual Seminar on Algebraic Matroids and Rigidity Theory. Spring 2020-

6. SIAM minisymposium co-organizer (with Carlos Améndola): *Algebraic geometry of low rank matrix completion* at the SIAM Conference on Applied Algebraic Geometry. Bern, Switzerland, July 9, 2019.

5. Co-organizer (with Diego Cifuentes) of the MIT IDSS seminar in Algebra, Statistics and Optimization. Spring 2019-

4. Co-organizer (with Greg Blekherman and Rainer Sinn) of a working group in matrix completion at Brown University, ICERM (Fall 2018)

3. AMS special session co-organizer (with Nathaniel Bushek and Mateja Raic): *AMS Special Session on Algebraic Statistics (a Mathematics Research Communities Session)* at the Joint Mathematics Meetings. Atlanta GA, January 5, 2017.

2. Conference co-organizer (with Eva Brayfindley, Amanda Laubmeier, Molly Lynch, and Kristen Moody): *Second Triangle Area Math Graduate Conference.* Raleigh NC, October 24, 2015.

1. Conference co-organizer (with Eva Brayfindley, Amanda Laubmeier, Molly Lynch, Kristen Moody, Radmila Sazdanovic, and Seth Sullivant): *First Triangle Area Math Graduate Conference.* Raleigh NC, March 21, 2015.

STUDENT MENTORING

1. Ian Limarta, MIT. Undergraduate research project in an application of matrix completion to fMRI studies.

CONFERENCES AND WORKSHOPS ATTENDED

33. *Discrete structures*, a Heilbronn focused research group at Lancaster University, UK (January 13-21, 2020)

32. *Algebra meets combinatorics*, University of Neuchâtel, Switzerland (July 15-17, 2019)

31. *SIAM conference on applied algebraic geometry*, Bern, Switzerland (July 9-13, 2019)

30. *Bi-annual algebraic and tropical meetings of Brown and Yale* at Yale (November 29, 2018)

29. *Applied Algebra Day* at Massachusetts Institute of Technology (November 17, 2018)
28. *Nonlinear Algebra in Applications* at Brown University, ICERM (November 12-16, 2018)
27. *Real Algebraic Geometry and Optimization* at Brown University, ICERM (October 15-19, 2018)
26. *Algebraic Geometry Northeastern Series* at Brown University (September 21-23, 2018)
25. *Core Computational Methods* at Brown University, ICERM (September 17-21, 2018)
24. *Nonlinear Algebra Bootcamp* at Brown University, ICERM (September 5-12, 2018)
23. *SIAM Annual Meeting* in Portland, OR (July 9-13, 2018)
22. *AMS Spring Eastern Sectional Meeting* at Northeastern University (April 21-22, 2018)
21. *AMS Fall Southeastern Sectional Meeting* at University of Central Florida (September 23-24, 2017)
20. *SIAM Conference on Applied Algebraic Geometry* at Georgia Tech (July 31-August 4, 2017)
19. *NSF/CBMS Conference on Tensors and Their Uses in Approximation Theory, Quantum Information Theory and Geometry* at Auburn University (July 24-28, 2017)
18. *Algebraic and Combinatorial Phylogenetics* at Barcelona Graduate School of Mathematics (June 26-30, 2017)
17. *Interactions Between Algebra and the Sciences* at Max Planck Institute for Mathematics in the Sciences, Leipzig, Saxony, Germany (June 27, 2017)
16. *Computing in Tropical Geometry* at Zuse Institute Berlin (May 11-12, 2017)
15. *Joint Mathematics Meetings* (January 4 - 7, 2017)
14. *MSRI Summer School on Tropical Curves and Chip Firing* (July 25 - August 5, 2016).
13. *SIAM Annual Meeting* in Boston, MA (July 11 - 15, 2016).
12. *Summer School on Algebra, Statistics, and Combinatorics* at Aalto University, Helsinki, Finland (June 27 - July 2, 2016).
11. AMS *Mathematical Research Communities in Algebraic Statistics*, Snowbird UT (June 12-18, 2016).
10. *Meeting on Algebraic Geometry for Applications* at Clemson University, (April 9, 2016).
9. *AMS Fall Central Sectional Meeting* at Loyola University Chicago. (October 3-4, 2015).
8. Macaulay2 Workshop at Boise State University (May 27-30,2015)
7. *Forty-Sixth Southeastern International Conference on Combinatorics, Graph Theory, and Computing* at Florida Atlantic University (March 2-6, 2015)
6. *NSF/CBMS Conference on Mathematical Phylogeny* at Winthrop University (June 28 - July 22, 2014)
5. *Algebraic Statistics* at Illinois Institute of Technology (May 19-22, 2014)
4. *Joint Mathematics Meetings* (Jan 15-18, 2014)
3. *MAA Southeastern Section Spring Meeting* at Winthrop University (Spring 2013)
2. *MAA Southeastern Section Spring Meeting* at Clayton State University (Spring 2012)
1. Workshop in Epidemic Models at SAMSI and NCSU (May 16 - 20, 2011)

JOURNALS REFEREED

American Mathematical Monthly; SIAM Journal on Applied Algebra and Geometry; Journal of Algebraic Statistics; Forum of Mathematics, Sigma; Journal of Combinatorial Theory, Series B

OTHER PROFESSIONAL SERVICE AND OUTREACH

Massachusetts Institute of Technology, Institute for Data, Systems, and Society

2. Mentor to 3 graduate students in the IDSS postdoc/graduate student mentoring program (Fall 2019-)
1. LIDS social committee (Spring 2019)

North Carolina State University, Mathematics Department

5. Judge at the MAA poster session for undergraduate research at the 2017 JMM (January 6, 2017)

4. Co-organizer (with Emily Barnard) of NCSU's Graduate Student Algebra and Combinatorics Seminar (Fall 2014 - Spring 2017)
3. *Math Circle* (assistant), May 3, 2014
2. *AMS Graduate Student Chapter*, Fall 2013 - Spring 2016
    -Organize professional development and networking events for graduate students including a semesterly conference (see conference organizing)
    -President: Fall 2014 - Spring 2016, Treasurer: Fall 2013 - Fall 2014
1. *Math Doesn't Bug Me Team* (volunteer), Fall 2013 - Present
    -Outreach events for children in elementary and middle school

Davidson College, Mathematics Department

1. *Bernard Society* (officer), Fall 2012 - Spring 2013
    -Organize departmental events

TEACHING EXPERIENCE

Duke University Department of Mathematics

1. *Real Analysis* (co-instructor): Fall 2020

North Carolina State University Mathematics Department

3. *Calculus III* (Instructor of Record): Spring 2016, Fall 2016, Spring 2017, Fall 2017
2. *Calculus for Life and Management Sciences* (Recitation Leader): Spring 2014 and Fall 2014
1. *Applied Differential Equations* (Lecture Assistant): Fall 2013

Davidson College

2. *Center for Teaching and Learning* (math and computer science tutor), Fall 2011 - Spring 2013
1. *Programming and Problem Solving* (homework grader), Fall 2010

PROFESSIONAL DEVELOPMENT FOR TEACHING

2. NCSU graduate student teaching assistant spring workshop (May 7, 2014)
1. NCSU graduate student teaching assistant fall workshop (August 14-18, 2014)

MEMBERSHIPS

2. American Mathematical Society (AMS)
1. Society for Industrial and Applied Mathematics (SIAM)

PROGRAMMING LANGUAGES

Proficient in Java, C, C++, R, Python, Sage, Macaulay2, Mathematica

REFERENCES

Greg Blekherman
Professor of Mathematics
Georgia Institute of Technology
greg@math.gatech.edu

Seth Sullivant (Ph.D. Advisor)
Distinguished Professor of Mathematics
North Carolina State University
smsulli2@ncsu.edu

Louis Theran
Lecturer in Mathematics
University of St. Andrews
lst6@st-andrews.ac.uk

Caroline Uhler
Henry L. and Grace Doherty Associate Professor
Massachusetts Institute of Technology
cuhler@mit.edu

Cynthia Vinzant
Assistant Professor of Mathematics
North Carolina State University
clvinzan@ncsu.edu

Walter Whiteley
Professor Emeritus of Mathematics
York University
whiteley@mathstat.yorku.ca