# DANIEL IRVING BERNSTEIN

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**Research keywords:** Nonlinear algebra, applied algebraic geometry, convex and discrete geometry, tropical geometry, matrix completion, rigidity theory, algebraic statistics, phylogenetics, graphical models

## EDUCATION

| | | |
|---|---|---|
| 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*) |

## EMPLOYMENT

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| 2021 – | Assistant Professor, Tulane University |
| 2021 | Jerrold E. Mardsen Postdoc, Fields Institute |
| 2020 | Research Associate, Duke University |
| 2018 – 2021 | NSF Postdoc, Massachusetts Institute of Technology (Mentor: Caroline Uhler) |
| 2018 | ICERM Postdoc, Brown University |

## HONORS AND AWARDS

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|---|---|
| 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 | Davidson College William G. McGavock Mathematics Award |
| 2013 | Patterson Prize for talk given at the MAA Southeastern Section Spring Meeting |

## PAPERS

### Submitted papers and preprints

18. Computing maximum likelihood thresholds using graph rigidity (with Sean Dewar, Steven J. Gortler, Anthony Nixon, Meera Sitharam, and Louis Theran). arXiv:2210.11081.
17. Maximum likelihood thresholds via graph rigidity (with Sean Dewar, Steven J. Gortler, Anthony Nixon, Meera Sitharam, and Louis Theran). arXiv:2108.02185.

### Journal Papers

16. $K_{5,5}$ is fully reconstructible in $\mathbb{C}^3$ (with Steven J. Gortler). *Discrete Applied Mathematics*, to appear. arXiv:2110.10224.
15. Generic symmetry-forced infinitesimal rigidity: translations and rotations. *SIAM Journal on Applied Algebra and Geometry*, 6 (2), 190-215. arXiv:2003.10529.
14. Typical ranks in symmetric matrix completion (with Greg Blekherman and Kisun Lee). *Journal of Pure and Applied Algebra*, Volume 225, Issue 7, July 2021. arXiv:1909.06593
13. 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
12. 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

11. The tropical Cayley-Menger variety (with Robert Krone). *SIAM Journal on Discrete Mathematics*, **33** (2019) no.3, pp. 1725–1742. arXiv:1812.09370
10. 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
9. 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
8. Completion of tree metrics and rank 2 matrices. *Linear Algebra and its Applications*. **533** (2017), pp. 1-13. arXiv:1612.06797
7. 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
6. Unimodular binary hierarchical models (with Seth Sullivant). *Journal of Combinatorial Theory, Series B*. **123** (2017), pp. 97-125. arXiv:1502.06131
5. Normal binary hierarchical models (with Seth Sullivant). *Experimental Mathematics*. **26** (2017) no. 2 pp. 153-164. arXiv:1508.05461
4. 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
3. 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

**Conference products**

2. On Alignment in Deep Linear Neural Networks (with Adit Radhakrishnan, Eshaan Nichani, and Caroline Uhler). Companion paper to a poster presented at *ICML Workshop on "Over-Parameterization: Pitfalls and Opportunities" (ICML 2021)*. arXiv:2003.06340
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

## EXPOSITORY WRITING

1. Matroids on graphs in applied algebraic geometry. Matroid Union blog, guest post, January 2021. `http://matroidunion.org/?p=3675`.

## TALKS

**Invited conference and colloquium talks**

39. *Maximum likelihood thresholds of Gaussian models.* January 4, 2023. Joint Math Meetings in Boston.
38. *Algebraic matroids and tropical geometry.* December 6, 2022. BIRS workshop 22w5022 on toric degenerations. Banff, Alberta, Canada.
37. *Maximum likelihood thresholds via graph rigidity.* July, 2022. British Combinatorial Conference, minisymposium on Matroids and Combinatorial Geometry, at Lancaster University, England, UK.
36. *Maximum likelihood thresholds via graph rigidity.* May 19, 2022. Algebraic Statistics at University of Hawai'i Manoa, Honolulu, HI.
35. *Rigidity theory for Gaussian graphical models: the maximum likelihood threshold of a graph.* June 10, 2021. Minisymposium on low-rank models and applications virtually "at" the Fields Institute, Toronto, Canada.
34. *Rigidity of plane frameworks with forced symmetry.* March 10, 2021. Pure mathematics colloquium, virtually "at" University of St. Andrews, Scotland.
33. *Generic symmetry-forced infinitesimal rigidity: translations and rotations.* February 24, 2021. Workshop on progress and open problems in rigidity theory, virtually "at" The Fields Institute, Toronto.

32. *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.
31. 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.
30. *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.
29. *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.
28. *Tropical geometry in rigidity theory.* January 13, 2020. Discrete structures, a Heilbronn focused research group. Lancaster University, UK.
27. *Algebraic matroids in rigidity theory and matrix completion.* December 6, 2019. Matroids Day. University of Wisconsin-Madison.
26. *The tropical Cayley-Menger variety.* July 17, 2019. Algebra meets combinatorics in Neuchatel. University of Neuchatel, Switzerland.
25. **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).
24. *Nonlinear algebra and matrix completion.* November 16, 2018. Nonlinear algebra in applications workshop at Brown University, ICERM.
23. *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.
22. *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.
21. *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.
20. *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
19. *Tropical linear spaces in phylogenetics.* May 27, 2017. Interactions between algebra and the sciences. Max Planck Institute for Mathematics in the Sciences. Leipzig, Germany
18. *Combinatorial properties of hierarchical models.* July 11, 2016. SIAM Annual Meeting, minisymposium on algebraic statistics
17. *Toric Varieties in Statistics.* April 9, 2016. Meeting on Algebraic Geometry for Applications. Clemson University. Clemson, SC.
16. *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**

15. Algebra and combinatorics seminar at Tulane University (October 20 and 27, 2021)
14. Algebra, geometry, and topology seminar at Tulane University (October 4, 2021)
13. Matroid union online seminar (April 19, 2021)
12. Guest lecture in Tony Nixon's graduate course on combinatorial and geometric rigidity virtually "at" the Fields Institute (February 5, 2021)
11. Study Group on Graph Theory, Topology and Algorithms virtually "at" The University of Birmingham (January 25, 2021)

10. Connections between graphical models and rigidity theory "at" The Fields Institute (January 22, 2021)
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

10. Workshop on geometric constraints: materials, graphs and matroids, rigidity and packings. Fields Institute, Toronto CA. July 10-14 2023.
9. Workshop at Tulane for math graduate students on how to plan your graduate school career with an eye towards job market success. January 11, 2023.
8. Special session co-organizer (with Zvi Rosen) at the Southeastern International Conference on Combinatorics, Graph Theory, and Computing: *Matroids and rigidity theory.* March 7-11, 2022
7. Organizer of the Virtual Seminar on Algebraic Matroids and Rigidity Theory. Spring 2020-Fall 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.

## TEACHING EXPERIENCE

### Tulane University Department of Mathematics

3. *Geometric Combinatorics* (graduate topics course): Fall 2022
2. *Abstract Algebra 2* (graduate level): Spring 2022
1. *Abstract Algebra 1* (graduate level): Fall 2021

### Duke University Department of Mathematics

1. *Real Analysis* (co-instructor with Mike Reed and Inmaculada C. Sorribes): 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

## STUDENT MENTORING

2. Hayden Outlaw, Tulane University. Undergraduate research project on Gaussian graphical model selection in the high-dimensional setting. Fall 2021-present.
1. Ian Limarta, MIT. Undergraduate research project in an application of matrix completion to fMRI studies. Summer 2019.

## 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