Joe Kileel

Curriculum Vitae

April 9, 2024

Contact Information

PMA 12.154 & POB 3.434

University of Texas at Austin

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Appointments

University of Texas at Austin
Assistant Professor, Department of Mathematics and Oden Institute for Computational Engineering and Sciences, Fall 2020–present

Princeton University
Postdoctoral Fellow, Program in Applied and Computational Mathematics, Simons Collaboration on Algorithms and Geometry, 2017–2020

Education

University of California, Berkeley
Ph.D. in Mathematics, 2012–2017

University of Cambridge
M.Math. and B.A. in Mathematics, 2008–2012

Research Interests

Broad: applied mathematics, computational algebra

Specific: 3D reconstruction in cryo-electron microscopy and computer vision; tensors; method of moments; nonconvex landscapes; applied algebraic geometry

Papers

30. "Algebraic constraints on common lines with applications to community detection in cryo-EM", T. Muller, A. Duncan, E. Verbeke, J. Kileel, arXiv:2403.16879

29. "Moment-based metrics for molecules computable from cryo-EM images", A. Zhang, O. Mickelin, J. Kileel, E. Verbeke, N. Marshall, M.A. Gilles, A. Singer, *Biological Imaging* (2024), pp. 1-22

28. "Covering number of real algebraic varieties and beyond: Improved bounds and applications", Y. Zhang, J. Kileel, arXiv:2311.05116

27. "Condition numbers in multiview geometry, instability in relative pose estimation, and RANSAC", H. Fan, J. Kileel, B. Kimia, arXiv:2310.02719

26. "The G-invariant graph Laplacian Part I: Convergence rate and eigendecomposition", E. Rosen, P. Hoyos, X. Cheng, J. Kileel, Y. Shkolnisky, *Applied and Computational Harmonic Analysis*, **71** (2024) pp. 1-35.

25. "Moment varieties for mixtures of products", Y. Alexandr, J. Kileel, B. Sturmfels, *ACM International Symposium on Symbolic and Algebraic Computation 2023*, pp. 53-60

24. "Moment estimation for nonparametric mixture models through implicit tensor decompostion", Y. Zhang, J. Kileel, *SIAM Journal on Mathematics of Data Science*, **5** 4 (2023), pp. 1130–1159

23. "Snapshot of algebraic vision", J. Kileel, K. Kohn, arXiv:2210.11443

22. "Autocorrelation analysis for cryo-EM with sparsity constraints: improved sample complexity and projection-based algorithms", T. Bendory, Y. Khoo, J. Kileel, O. Mickelin, A. Singer, *Proceedings of the National Academy of Sciences* **120** 18 (2023), e2216507120

21. "The effect of smooth parametrizations on nonconvex optimization landscapes", E. Levin, J. Kileel, N. Boumal, *Mathematical Programming* (2024) pp. 1-49

20. "Scalable symmetric Tucker tensor decomposition", R. Jin, J. Kileel, T. Kolda, R. Ward, *SIAM Journal on Matrix Analysis and Applications* (to appear), arXiv:2204.10824

19. "Tensor moments of Gaussian mixture models: theory and applications", J. Pereira, J. Kileel, T. Kolda, arXiv:2202.06930

18. "On the instability of relative pose estimation and RANSAC's role", H. Fan, J. Kileel, B. Kimia, *IEEE Conference on Computer Vision and Pattern Recognition 2022*, pp. 8935–8943

17. "Finding stationary points on bounded-rank matrices: a geometric hurdle and a smooth remedy", E. Levin, J. Kileel, N. Boumal, *Mathematical Programming*, online June 24, 2022, pp. 1–34

16. "Landscape analysis of an improved power method for tensor decomposition", J. Kileel, T. Klock, J. Pereira, *Advances in Neural Information Processing Systems 2021*, pp. 6253–6265

15. "Manifold learning with arbitrary norms", J. Kileel, A. Moscovich, N. Zelesko, A. Singer, *Journal of Fourier Analysis and Applications* **27** 82 (2021), pp. 1-56

14. "Subspace power method for symmetric tensor decomposition and generalized PCA", J. Kileel, J. Pereira, arXiv:1912.04007

13. "Earthmover-based manifold learning for analyzing molecular conformation spaces", N. Zelesko, A. Moscovich, J. Kileel, A. Singer, *IEEE International Symposium on Biomedical Imaging 2020*, pp. 1715-1719

12. "Method of moments for 3-D single particle *ab initio* modeling with non-uniform distribution of viewing angles", N. Sharon, J. Kileel, Y. Khoo, B. Landa, A. Singer, *Inverse Problems* **36** 044003 (2020), pp. 1-40

11. "On the expressive power of deep polynomial neural networks", J. Kileel, M. Trager, J. Bruna, *Advances in Neural Information Processing Systems 2019*, pp. 10310-10319

10. "Estimation under group actions: recovering orbits from invariants", A. Bandeira, B. Blum-Smith, J. Kileel, A. Perry, J. Weed, A. Wein, *Applied and Computational Harmonic Analysis*, **66** (2023), pp. 236-319

9. "3D *ab initio* modeling in cryo-EM by autocorrelation analysis", E. Levin, T. Bendory, N. Boumal, J. Kileel, A. Singer, *IEEE International Symposium on Biomedical Imaging 2018*, pp. 1569–1573

8. "Numerical implicitization", J. Chen, J. Kileel, *Journal of Software for Algebra and Geometry* **9** (2019), pp. 55-63

7. "Distortion varieties", J. Kileel, Z. Kukelova, T. Pajdla, B. Sturmfels, *Foundations of Computational Mathematics* **18** (2018), pp. 1043-1071

6. "The Chow form of the essential variety in computer vision", G. Fløystad, J. Kileel, G. Ottaviani, *Journal of Symbolic Computation* **86** (2018), pp. 97-119

5. "Algebraic geometry for computer vision", J. Kileel, *University of California, Berkeley* (2017), Ph.D. thesis, pp. 1–139

4. "Minimal problems for the calibrated trifocal variety", J. Kileel, *SIAM Journal on Applied Algebra and Geometry* **1** (2017), pp. 575-598

3. "A clever elimination strategy for efficient minimal solvers", Z. Kukelova, J. Kileel, B. Sturmfels, T. Pajdla, *IEEE Conference on Computer Vision and Pattern Recognition 2017*, pp. 3605–3614

2. "Rigid multiview varieties", M. Joswig, J. Kileel, B. Sturmfels, A. Wagner, *International Journal of Algebra and Computation* **26** (2016), pp. 775–788

1. "Hadamard products of linear spaces", C. Bocci, E. Carlini, J. Kileel, *Journal of Algebra* **448** (2016), pp. 595—617

Research Funding

- NSF Award DMS 2309782, Continuing Grant in Computational Mathematics Program, 2023–2026, PI, $275k
- NSF Award CISE-IIS 2312746, Collaborative Research Grant in Robust Intelligence Program, 2023–2027, Co-PI, $91k personally

Honors

- Charles Chui Young Researcher Best Paper Award 2023
- Program Fellow (in-residence), Institute for Pure and Applied Mathematics, University of California, Los Angeles, Computational Microscopy, Fall 2022
- Simons Postdoctoral Fellowship, Collaboration on Geometry and Algorithms, 2017–2020
- Bernard Friedman Memorial Prize for Best Thesis in Applied Mathematics, University of California, Berkeley, 2017
- Blyth Cambridge Commonwealth Scholarship, 2008–2011 (two in Canada)

Teaching

- Spring 2024: CSE 382M / M 393C "Foundational Techniques of Machine Learning and Data Sciences" (graduate course)
- Fall 2023: M 348 "Scientific Computation in Numerical Analysis" (undergraduate course)
- Spring 2023: CSE 382M / M 393C "Foundational Techniques of Machine Learning and Data Sciences" (graduate course)

- Spring 2022: M 348 "Scientific Computation in Numerical Analysis" (undergraduate course)
- Fall 2021: M 392C / CSE 392 "Geometric Methods in Data Science" (graduate course)
- Spring 2020: M 365C "Real Analysis I" (undergraduate course)
- Graduate reading courses on: nonlinear algebra and computational algebraic geometry; group synchronization; manifold learning; computational geometry

Advising

Postdocs

- Julia Lindberg: January 2023–present. Bing Instructor in Department of Mathematics.
- João M. Pereira: January 2021–2022. Co-mentored by Rachel Ward. Oden Institute Postdoc. Next: tenure-track assistant professor at IMPA, Brazil.

Ph.D. students

- Gabriel Brown: Oden Inst, 2023–present. Tensor approximations, well-posedness.
- Adriana Duncan: Math Dept., 2023–present. Group synchronization, higher-order networks.
- Paulina Hoyos: Math Dept., 2022–present. Diffusion maps, applications of representation theory, dimensionality reduction in cryo-electron microscopy.
- Elzbieta Polak: Math Dept., 2021–present. Distance-to-group-orbits problems, computational algebra, signal processing.
- Yifan Zhang: Oden Inst., 2021–present. Tensor decompositions, mixture models, numerical optimization, real algebraic varieties.
- George D. Torres: Math Dept., 2022–2023. Co-advised by Ngoc Tran. Dissertation title: "Zonotope Matching and Approximation for Neural Networks". Next: research scientist at Striveworks.

Undergraduates

- Bronson Zhou: 2021–2022. Fast transforms, computing with molecules. Class of '23, Babuška scholarship. Next: Ph.D. student at Yale's Statistics & Data Science department.
- Eitan Levin: 2019–2020. Co-advised by Nicolas Boumal. Optimization on varieties. Class of '20, thesis prize (Princeton). Next: Ph.D. student at Caltech's Applied and Computational Mathematics program with Venkat Chandrasekaran and Joel Tropp.
- Changshuo Liu: 2018–2019. Method of moments, cryo-EM, tensors. Class of '19, thesis prize (Princeton). Next: quantitative financial researcher at GTS.

Talks

(since 2018)

89. Joint Mathematics Meeting, Special Session on Algebraic Statistics, Seattle, January 2025
88. SIAM Conference on Mathematics of Data Science, Minisymposium on Algebraic Geometry and Machine Learning, Atlanta, October 2024
87. BIRS-CMO Workshop on Computational Harmonic Analysis in Data Science and Machine Learning, Casa Matemática Oaxaca, September 2024
86. International Symposium on Mathematical Programming, Montreal, July 2024
85. NSF CompMath PI meeting, University of Washington, July 2024
84. Workshop on Tensors: Algebra, Geometry and Applications, Colorado State University, Mountain Campus, June 2024
83. Joint Mathematics of Data & Decisions and Algebraic Geometry Seminar, University of California, Davis, March 2024
82. Codes and Expansions (CodEx) Seminar, March 2024 (virtual)
81. Winter Program in ML, University of Texas at Austin, Department of Mathematics, January 2024 (mini-course)
80. Topical Workshop on Higher-Order Statistics and Symmetric Tensors, Institute for Computational and Experimental Research in Mathematics, January 2024
79. Joint Mathematics Meeting, Special Session on Mathematics of Computer Vision, San Francisco, January 2024
78. Tensor Methods Reunion Conference, Institute for Pure and Applied Mathematics, December 2023
77. Bayesian Statistics and Statistical Learning Workshop, Institute for Mathematical and Statistical Innovation, December 2023
76. PSU-Purdue-UMD Joint Seminar on Mathematical Data Science, November 2023 (virtual)
75. Annual Meeting of SIAM TX-LA Section, University of Louisiana at Lafayette, November 2023
74. FFT Conference, Norbert Wiener Center for Harmonic Analysis and Applications, University of Maryland, College Park, October 2023
73. Tutorial Lecture, Invitation to Algebraic Statistics and Applications, Institute for Mathematical and Statistical Innovation, September 2023
72. Applied Inverse Problems Conference, Minisymposium on Mathematical Methods for Cryo-EM, Göttingen, September 2023
71. Mathematical Methods for Exploring and Analyzing Morphological Shapes across Biological Scales, Banff International Research Station, September 2023
70. International Council for Industrial and Applied Mathematics, Minisymposium on Randomized Numerical Linear Algebra, Tokyo, August 2023
69. SIAM Conference on Applied Algebraic Geometry, Minisymposium on Applications of Tensors, Eindhoven, July 2023
68. SIAM Conference on Optimization, Minisymposium on Nonconvex Landscapes, Seattle, June 2023
67. Oden Institute Seminar, University of Texas at Austin, May 2023
66. SIAM Conference on Computational Science and Engineering, Minisymposium on 3D Reconstruction, Amsterdam, February 2023

65. Topics in Algebra, Topology, Etc., Research Seminar, Boise State University, February 2023 (virtual)
64. Alan Turing-Oden Institutes Workshop, London, UK, January 2023
63. Visit D. Edidin and Colloquium, Department of Mathematics, University of Missouri, January 2023
62. Joint Mathematics Meeting, Special Session on Data Science, Special Session on Homotopy Continuation, Special Session on Tensors, Boston, January 2023
61. Colloquium, Department of Mathematics, University of Texas at Austin, December 2022
60. Colloquium, Program in Applied and Computational Mathematics, Princeton University, November 2022
59. Cryo-Electron Microscopy and Beyond Workshop, Institute for Pure and Applied Mathematics, University of California, Los Angeles, November 2022
58. Data and Learning Seminar, Instituto de Matemática Pura e Aplicada, Brazil, November 2022
57. Mathematical Machine Learning Seminar, Max Planck Institute for Mathematics in the Sciences + University of California, Los Angeles, October 2022 (virtual)
56. SIAM Conference on Mathematics of Data Science, Minisymposium on Optimal Transport, San Diego, September 2022 (virtual)
55. ML + X Seminar, Institute for Foundations of Machine Learning, University of Texas at Austin, September 2022
54. Combinatorial, Computational, and Applied Algebraic Geometry Conference, University of Washington, June 2022
53. Workshop on Mathematical and Computational Challenges in Cryogenic Electron Microscopy, University of British Columbia, May 2022
52. AMS Special Session, Tufts University, March 2022 (virtual)
51. IMA Data Science Seminar, University of Minnesota, February 2022
50. Algebraic Geometry Seminar, UC Davis, January 2021 (virtual)
49. Conference on Neural Information Processing Systems, December 2021 (virtual)
48. Applied Mathematics Seminar, Yale University, November 2021 (virtual)
47. SIAM Texas-Louisiana Sectional Meeting, University of Texas at Rio Grande Valley, Minisymposium on Algorithmic Algebra and Geometry, November 2021
46. BIRS-CMO Workshop on Geometry & Learning from Data, Casa Matemática Oaxaca, October 2021 (virtual)
45. Computational and Applied Mathematics Colloquium, University of Chicago, October 2021
44. SIAM Conference on Applied Algebraic Geometry, Texas A&M University, Minisymposium on Algebraic Geometry and Machine Learning, August 2021 (virtual)
43. Data Science Seminar, University of Oxford, June 2021 (virtual)
42. Tensors Seminar Series, Institute for Pure and Applied Mathematics, University of California, Los Angeles, May 2021 (virtual)
41. Applied and Computational Mathematics Seminar, National University of Singapore, March 2021 (virtual)
40. Tsinghua Sanya International Mathematics Forum, Workshop on Algebraic Geometry and Machine Learning, January 2021 (virtual)
39. Geometry Seminar, Texas A&M University, November 2020 (virtual)
38. Babuška Forum, University of Texas At Austin, Oden Institute for Computational Enginering and Sciences, November 2020 (virtual)

37. DeepMath, Conference on Mathematical Theory of Deep Neural Networks, Poster Presentation, November 2020 (virtual)
36. SIAM Texas–Louisiana Section, Texas A&M University, Minisymposium on Applications of Algebraic Geometry and Minisymposium on Algebraic, Geometric, and Combinatorial Methods in Mathematical Biology, October 2020 (virtual)
35. Algebraic Statistics Online Seminar, September 2020 (virtual)
34. SIAM Conference on Mathematics of Data Science, Cincinnati, Special Session on Algebraic Geometry and Machine Learning, June 2020 (virtual)
33. Colloquium, School of Mathematics, Georgia Institute of Technology, March 2020
32. Colloquium, Division of Applied Mathematics, Brown University, February 2020
31. Colloquium, Courant Institute of Mathematical Sciences, New York University, February 2020
30. Colloquium, Department of Mathematics, University of Wisconsin–Madison, February 2020
29. Colloquium, Department of Mathematics, Duke University, January 2020
28. Colloquium, Department of Mathematics, Rutgers University–New Brunswick, January 2020
27. Analysis Seminar, Department of Mathematics, University of Texas at Austin, January 2020
26. Colloquium, Oden Institute for Computational Engineering and Sciences, University of Texas at Austin, January 2020
25. Colloquium, Department of Mathematics, University of Toronto, January 2020
24. Conference on Neural Information Processing Systems, December 2019
23. Joint Applied Mathematics/Statistics & Data Science Seminar, Yale University, December 2019
22. Novel Medical Imaging Workshop, Texas A&M University, November 2019
21. Linear Algebra Seminar, Auburn University, November 2019
20. Algebra Seminar, University of Washington, Seattle, October 2019
19. SIAM Pacific Northwest Section, Seattle University, Special Session on Algebra, Geometry and Applications, October 2019
18. AMS Sectional Meeting, University of Wisconsin–Madison, Special Session on Applications of Algebra and Geometry, September 2019
17. Big Data Conference, Center of Mathematical Sciences and Applications, Harvard University, August 2019
16. NYC Computational Cryo-EM Summer Workshop, Center for Computational Mathematics, Flatiron Institute, August 2019
15. SIAM Conference on Applied Algebraic Geometry, Universität Bern, Switzerland, Minisymposium on Algebraic Vision, July 2019
14. Computational and Applied Mathematics Colloquium, University of Chicago, May 2019
13. Applied Algebra Seminar, University of Wisconsin–Wisconsin, May 2019
12. Algebra Seminar, Georgia Institute of Technology, April 2019
11. AMS Sectional Meeting, Auburn University, Special Session on Applications of Algebraic Geometry, March 2019
10. Algebraic Vision Research Cluster, Institute for Computational and Experimental Research in Mathematics, Brown University, January 2019
9. Joint CUNY Graduate Center-Courant Seminar, Symbolic-Numeric Computing, City University of New York, December 2018

8. Mathematics, Information and Computation Seminar, Center for Data Science, New York University, November 2018
7. Nonlinear Algebra Seminar, Institute for Computational and Experimental Research in Mathematics, Brown University, November 2018
6. Math and Data Working Group at Center for Data Science, New York University, October 2018
5. AMS Sectional Meeting, University of Michigan, Ann Arbor, Special Session on Extensions-Interpolation-Shape Matching in $\mathbb{R}^d$, Symmetry-Invariance, Algorithms and Related Topics, October 2018
4. Dagstuhl Seminar, Leibniz-Zentrum für Informatik, Shape Analysis: Euclidean, Discrete and Algebraic Geometric Methods, October 2018
3. Joint KMS-DMV Mathematics Conference in Seoul, Special Session on Algebraic Geometry and Computer Vision, October 2018
2. Simons Collaboration on Algorithms and Geometry, Simons Foundation, New York, March 2018.
1. SIAM Southeastern Atlantic Sectional Conference, University of North Carolina at Chapel Hill, Special Session on Topics in the Mathematics of Data Analysis, March 2018

Patent

"Fully Automatic, Template-Free Particle Picking for Electron Microscopy", A. Singer, A. Heimowitz, J. Anden, Y. Khoo, J. Kileel

– USA Patent, No.: 11,557,034 B2. Patent date: January 17, 2023

– China Patent, No.: ZL201880046702.X. Patent date: April 28, 2023

Service

- Referee for journals, including: SIAM Journal on Applied Algebra and Geometry, SIAM Journal on Mathematics of Data Science, SIAM Journal on Imaging Science, SIAM Journal on Optimization, Mathematical Programming, Advances in Mathematics, Advances in Computational Mathematics, Journal of Algebra, Experimental Mathematics, Journal of Machine Learning Research, Nature Communications, Journal of AMS (quick opinion), Memoirs of AMS (quick opinion)
- Referee for conferences, including: NeurIPS, CVPR, STOC, FOCS
- Referee for volumes: Springer's Applied and Numerical Harmonic Analysis
- Co-organized "Winter Program in ML", University of Texas at Austin, Department of Mathematics, January 2024

- Co-organized workshop "Connecting Higher-Order Statistics and Symmetric Tensors", Institute for Computational and Experimental Research in Mathematics, Brown University, January 2024
- Co-organized minisymposium "Parameterizations and Nonconvex Landscapes", SIAM Conference on Optimization, University of Washington, June 2023
- Co-organized minisymposium "Data-Driven Scientific Computing", SIAM Conference on Computational Science and Engineering, Fort Worth, Texas, March 2021 (virtual)
- Co-organized minisymposium "Theoretical and Computational Aspects of the Method of Moments", SIAM Conference on Mathematics of Data Science, Cincinnati, June 2020 (virtual)
- Organizing seminar "Applied Math" for UT students (Spring 2024)
- Organized seminar "Data & Algebra" for UT students (Spring 2022, Spring 2023, Fall 2023)
- Panel service: NSF Computational Mathematics (2024)
- Professional-track faculty chair's committee: Department of Mathematics (2023-2024)
- Professional-track faculty annual review committee: Department of Mathematics (2023-2024)
- Bing Instructor hiring committee: Department of Mathematics (2024)
- Ph.D. admissions: Department of Mathematics (2022), Oden Institute (2022, 2024)
- Ph.D. dissertation award nominations committee: Oden Institute (2023)
- Thesis proposal committees: Yijung Dong (advisors: Martinsson and Ward), Lewis Liu (advisor: Tsai), Minh Nguyen (advisor: Bajaj), Keith Poletti (advisors: Ward and Offner), Will Ruys (advisor: Biros), Bobby Shi (advisor: Ward), Casey Stowers (advisor: Yankeelov), Xin Tang (advisor: Baldea), Yuege Xie (advisor: Ward), Yi Wang (advisor: Bajaj)
- Supervising undergraduate certificates: Bryan Doan (scientific computation and data sciences, 2024)
- Prelim exam committee: Data Science test, Oden Institute (May 2023); Data Science retest, Oden Institute (July 2021)
- Course coordinator and QR flag proposer for M 348: Department of Mathematics (starting 2023)

- UT's CNS undergraduate commencement: served as marshal (2023)
- UT Dean's Scholars student association: undergraduate outreach presentation (2023)

References

- Bernd Sturmfels, bernd@mis.mpg.de
- Amit Singer, amits@math.princeton.edu
- Tamara G. Kolda, tammy.kolda@mathsci.ai
- Richard Bamler (teaching), rbamler@berkeley.edu