Dmitriy (Tim) Kunisky

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CONTACT INFORMATION

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RESEARCH INTERESTS

My focus is on probability theory and discrete mathematics with applications to statistics, data science, algorithms, and optimization. In particular:

· computationally-hard regimes in optimization and statistical problems;

· average-case analysis of convex relaxations of combinatorial optimization;

· random matrix theory, pseudorandom matrices, and random tensors;

· convex optimization in proof assistants and experimental mathematics;

· discrepancy theory and its algorithmic applications.

EMPLOYMENT

Johns Hopkins University — Baltimore, MD
Assistant Professor in Applied Mathematics & Statistics — 07/2024–Present

Yale University — New Haven, CT
Postdoctoral Associate in Computer Science — 07/2021–07/2024

· Hosted by Daniel Spielman

EDUCATION

Courant Institute of Mathematical Sciences — New York, NY
Ph.D. in Mathematics — 09/2016–05/2021

· Dissertation: *Spectral Barriers in Certification Problems*, advised by Afonso Bandeira and Gérard Ben Arous

Princeton University — Princeton, NJ
A.B. *summa cum laude* in Mathematics — 09/2010–06/2014

· Certificate in Applications of Computing

· Senior Thesis: *The Theft and the Honest Toil: Applications of Large Cardinal Axioms to the Theory of Measurable Selection*, advised by John Burgess

· Junior Independent Paper: *Discrete Applications of Brownian Motion*, advised by Michael Damron

PUBLICATIONS

Tensor cumulants for statistical inference on invariant distributions. Dmitriy Kunisky, Cristopher Moore, Alexander S. Wein. *Symposium on Foundations of Computer Science (FOCS)*, 2024 (to appear).

Computational hardness of detecting graph lifts and certifying lift-monotone properties of random regular graphs. Dmitriy Kunisky, Xifan Yu. *Symposium on Foundations of Computer Science (FOCS)*, 2024 (to appear).

Fitting an ellipsoid to random points: predictions using the replica method. Antoine Maillard, Dmitriy Kunisky. *IEEE Transactions on Information Theory*, 2024.

Optimality of Glauber dynamics for general-purpose Ising model sampling and free energy approximation. Dmitriy Kunisky. *ACM-SIAM Symposium on Discrete Algorithms (SODA)*, 2024.

Spectral pseudorandomness and the road to improved clique number bounds for Paley graphs. Dmitriy Kunisky. *Experimental Mathematics*, 2024.

On the concentration of Gaussian Cayley matrices. Afonso S. Bandeira, Dmitriy Kunisky, Dustin G. Mixon, Xinmeng Zeng. *Applied and Computational Harmonic Analysis (ACHA)* 73, November 2024.

A degree 4 sum-of-squares lower bound for the clique number of the Paley graph. Dmitriy Kunisky, Xifan Yu. *Computational Complexity Conference (CCC)*, 2023.

The spectrum of the Grigoriev-Laurent pseudomoments. Dmitriy Kunisky, Cristopher Moore. *SIAM J. Discrete Mathematics (SIDMA)* 38, No. 1, 2024.

Dual bounds for the positive definite functions approach to mutually unbiased bases. Afonso S. Bandeira, Nikolaus Doppelbauer, Dmitriy Kunisky. *Sampling Theory, Signal Processing, and Data Analysis* 20, No. 18, 2022.

The discrepancy of unsatisfiable matrices and a lower bound for the Komlŏs conjecture constant. Dmitriy Kunisky. *SIAM J. Discrete Mathematics (SIDMA)* 37, No. 2, 2023.

Strong recovery of geometric planted matchings. Dmitriy Kunisky, Jonathan Niles-Weed. *ACM-SIAM Symposium on Discrete Algorithms (SODA)*, 2022.

Average-case integrality gap for non-negative principal component analysis. Afonso S. Bandeira, Dmitriy Kunisky, Alexander S. Wein. *Mathematical and Scientific Machine Learning (MSML)*, 2021.

Hypothesis testing with low-degree polynomials in the Morris class of exponential families. Dmitriy Kunisky. *Conference on Learning Theory (COLT)*, 2021.

Spectral planting and the hardness of refuting cuts, colorability, and communities in random graphs. Afonso S. Bandeira, Jess Banks, Dmitriy Kunisky, Cristopher Moore, Alexander S. Wein. *Conference on Learning Theory (COLT)*, 2021.

Linear programming and community detection. Alberto Del Pia, Aida Khajavirad, Dmitriy Kunisky. *Mathematics of Operations Research*, 2022.

The average-case time complexity of certifying the restricted isometry property.

Yunzi Ding, Dmitriy Kunisky, Alexander S. Wein, Afonso S. Bandeira. *IEEE Transactions on Information Theory*, 2021.

A tight degree 4 sum-of-squares lower bound for the Sherrington-Kirkpatrick Hamiltonian. Dmitriy Kunisky, Afonso S. Bandeira. *Mathematical Programming* 190, No. 1, 2021.

Notes on computational hardness of hypothesis testing: predictions using the low-degree likelihood ratio. Dmitriy Kunisky, Alexander S. Wein, Afonso S. Bandeira. *ISAAC Congress*, 2019.

Subexponential-time algorithms for sparse PCA. Yunzi Ding, Dmitriy Kunisky, Alexander S. Wein, Afonso S. Bandeira. *Foundations of Computational Mathematics*, 2023.

Mapping political communities: a statistical analysis of lobbying networks in legislative politics. In Song Kim, Dmitriy Kunisky. *Political Analysis* 29, No. 3, 2021.

Computational hardness of certifying bounds on constrained PCA problems. Afonso S. Bandeira, Dmitriy Kunisky, Alexander S. Wein. *Innovations in Theoretical Computer Science (ITCS)*, 2020.

Connections between sum-of-squares optimization and structured tight frames. Afonso S. Bandeira, Dmitriy Kunisky. *SPIE Wavelets and Sparsity*, 2019.

Sum-of-squares optimization and the sparsity structure of equiangular tight frames. Afonso S. Bandeira, Dmitriy Kunisky. *Sampling Theory and Applications (SAMPTA)*, 2019.

Hysteresis control of epithelial-mesenchymal transition dynamics conveys a distinct program with enhanced metastatic ability. Toni Celià-Terrassa, Caleb Bastian, Daniel D. Liu, Brian Ell, Nicole M. Aiello, Yong Wei, Jose Zamalloa, Andres M. Blanco, Xiang Hang, Dmitriy Kunisky, Wenyang Li, Elizabeth D. Williams, Herschel Rabitz, Yibin Kang. *Nature Communications* 9, No. 1, 2018.

PREPRINTS   On the structure of bad science matrices. Alex Albors, Hisham Bhatti, Lukshya Ganjoo, Raymond Guo, Dmitriy Kunisky, Rohan Mukherjee, Alicia Stepin, Tony Zeng. arXiv:2408.00933, 2024.

Inference of rankings planted in random tournaments. Dmitriy Kunisky, Daniel A. Spielman, Xifan Yu. arXiv:2407.16597, 2024.

Computational lower bounds for multi-frequency group synchronization. Anastasia Kireeva, Afonso S. Bandeira, Dmitriy Kunisky. arXiv:2406.03424, 2024.

Low coordinate degree algorithms I: Universality of computational thresholds

for hypothesis testing. Dmitriy Kunisky. `arXiv:2403.07862`, 2024.

Average-case matrix discrepancy: Asymptotics and online algorithms. Dmitriy Kunisky, Peiyuan Zhang. `arXiv:2307.10055`, 2023.

Generic MANOVA limit theorems for products of projections. Dmitriy Kunisky. `arXiv:2301.09543`, 2023.

Positivity-preserving extensions of sum-of-squares pseudomoments over the hypercube. Dmitriy Kunisky. `arXiv:2009.07269`, 2020.

A Gramian description of the degree 4 generalized elliptope. Afonso S. Bandeira, Dmitriy Kunisky. `arXiv:1812.11583`, 2018.

INVITED TALKS

Towards a general theory of low degree algorithms in statistics. Georgia Tech Algorithms and Randomness Center (ARC) Colloquium, 2024.

Spectral pseudorandomness, free probability, and the clique number of the Paley graph. Ohio State University Data Science Seminar, 2024.

Computational hardness of testing for graph lifts and certifying properties of random regular graphs. CodEx Online Seminar, 2024.

Tensor networks, tensor cumulants, and tensor PCA. Johns Hopkins University Applied Mathematics and Statistics Seminar, 2024.

Computational hardness of testing for graph lifts and certifying properties of random regular graphs. Johns Hopkins University Computer Science Theory Seminar, 2024.

The finite free cumulants of a tensor and their statistical applications. Virtual Tensor Journal Club, 2024.

Low coordinate degree algorithms: a flexible framework for computational thresholds. Bocconi University Workshop on Conceptual Challenges in AI: from ML to Average-Case Computation and Cryptography, 2024.

Computational hardness of testing for graph lifts and certifying properties of random regular graphs. ETH Zurich Data, Algorithms, Combinatorics, and Optimization (DACO) Seminar, 2024.

Computational hardness of testing for graph lifts and certifying properties of random regular graphs. University of Chicago Computer Science Theory Seminar, 2024.

Universality of computational thresholds in hypothesis testing for low coordinate degree algorithms. AMS Spring Western Sectional Special Session on Random

Structures, Computation, and Statistical Inference, 2024.

Optimality of Glauber dynamics for general-purpose sampling and free energy approximation. CRM-ISM Montreal Probability Seminar, 2024.

Universal lower bounds against low-degree polynomials. BIRS Workshop on Computational Complexity of Statistical Inference, 2024.

Gramian constructions of sum-of-squares lower bounds and the spectra of pseudomoments. SIAM Conference on Applied Algebraic Geometry, 2023.

Spectral limit theorems for submatrices and products of projections. MIT Probability Seminar, 2023.

Spectral pseudorandomness and the clique number of the Paley graph. MIT Stochastics and Statistics Seminar, 2023.

What average-case optimzation can tell number theory. Lehigh University Engineering Seminar, 2023.

Spectral pseudorandomness and the clique number of the Paley graph. BIRS-CMO Workshop on Learning in Networks, CMO Oaxaca, 2022.

The degree 4 sum-of-squares relaxation of the clique number of Paley graphs. AMS Fall Western Sectional Special Session on Algebraic Combinatorics and Applications in Harmonic Analysis, 2022.

Dual bounds for the positive semidefinite functions approach to mutually unbiased bases. CodEx Online Seminar, 2022.

Strong recovery of geometric planted matchings. Workshop on Rigorous Evidence for Information-Computation Trade-Offs, Simons Institute for the Theory of Computing, 2021.

A positivity-first approach to sum-of-squares over the hypercube. Workshop on Computational Phase Transitions, Simons Institute for the Theory of Computing, 2020.

The low-degree method for identifying statistical-to-computational gaps. MOKA-PLAN Seminar, INRIA Paris, 2020.

Certifying bounds on random quadratic programs is hard. SIERRA Seminar, INRIA Paris, 2020.

Hardness of certification for random optimization problems. Computer Science Theory Seminar, Columbia University, 2019.

Hardness of certification for random optimization problems. Seminar on Algebra,

Statistics, and Optimization, MIT, 2019.

HONORS	US Junior Oberwolfach Fellow (NSF DMS-2230648)
	Predoctoral Summer Fellowship, New York University
	Graduate Research Initiative Award, New York University
	Student Government Conference Fund Award, New York University
	Harold Grad Memorial Prize, New York University
	Best Poster Award, Princeton Day of Optimization 2018
	Charles Newman Fellowship, New York University
	Honorable Mention, NSF Graduate Research Fellowship
	Phi Beta Kappa Society (Early Admission), Princeton University
	Shapiro Award for Academic Excellence, Princeton University

TEACHING	Random Matrix Theory in Data Science and Statistics Johns Hopkins University	Fall 2024
	Modern Probability for Theoretical Computer Science Yale University	Spring 2023
	Sum-of-Squares Optimization Yale University	Spring 2022
	Mathematical Statistics (Teaching Assistant) New York University	Fall 2020
	Discrete Mathematics (Teaching Assistant) New York University	Summer 2020
	Probabilistic Time Series Analysis (Teaching Assistant) New York University	Fall 2018
	Algebra II (Teaching Assistant) Princeton University	Spring 2013

SERVICE	Reviewed for publications: AMS Mathematical Reviews (MathSciNet), Annals of Probability, Annals of Statistics, Digital Signal Processing, Discrete & Computational Geometry, IEEE Transactions on Information Theory, IEEE Transactions on Signal Processing, Information and Inference: A Journal of the IMA, Information Processing Letters, Journal of Machine Learning Research (JMLR), Mathematical Programming, Mathematics of Operations Research, Operations Research, Political Analysis, Random Structures & Algorithms, SIAM Journal on Discrete Mathematics (SIDMA), SIAM Journal on Mathematics of Data Science (SIMODS).
	Reviewed for conferences: CCC (2021), COLT (2018), FOCS (2020, 2021, 2024), MSML (2020, 2021, 2022), RANDOM (2024), SODA (2022, 2024), STOC (2023, 2024).
	Organized Courant Institute student probability seminar, Fall 2018–Spring 2021.

| INDUSTRY | **Google, Inc.** | Mountain View, CA; New York, NY |
| EXPERIENCE | Software Engineer | 10/2014–07/2016 |

· Developed interactive semantic code differencing tools for working with complex search ranking algorithms.

· Improved machine learning infrastructure for semantic parsing tasks in natural language processing.