Zhichao Wang

Curriculum Vitae

Email: zhichao.wang@berkeley.edu

RESEARCH INTERESTS

Foundations of AI and Deep Learning, High-dimensional Probability, High-Dimensional Statistics
Explainable AI, Feature Learning for Transformers and Graph Neural Networks
Random Matrix Theory, Free Probability Theory, Random Graphs

EMPLOYMENT

University of California, Berkeley, USA *Postdoctoral Scholar, July 2024-present*

Department of Statistics and International Computer Science Institute
Advisor: Michael Mahoney

Simons Laufer Mathematical Sciences Institute, USA *Postdoctoral Fellow, January-May 2025*

Program: Probability and Statistics of Discrete Structures

EDUCATION

University of California San Diego, USA *Ph.D. in Mathematics, June 2024*

Advisors: Prof. Ioana Dumitriu and Prof. Todd Kemp

Texas A&M University, College Station, USA *MSc. in Mathematics, May 2018*

Advisor: Prof. Michael Anshelevich

Beihang University, Beijing, China *BSc. in Mathematics and Applied Mathematics, July 2017*

Hua Loo-Keng Honors Class, joint program with the Academy of Mathematics and Systems Science of Chinese Academy of Sciences. Exchange student at Texas A&M University (2016-2017).

PUBLICATIONS AND PREPRINTS

1. **Singular values of sparse random rectangular matrices: Emergence of outliers at criticality**
(with Ioana Dumitriu, Hai-Xiao Wang, Yizhe Zhu)
Submitted.

2. **Pep2Prob Benchmark: Predicting Fragment Ion Probability for MS^2-based Proteomics.**
(with Hao Xu, Shengqi Sang, Pisit Wajanasara, Nuno Bandeira)
Submitted. [Dataset] [Code]

3. **Generalization Bound of Gradient Flow through Training Trajectory and Data-dependent Kernel.**
(with Yilan Chen, Wei Huang, Andi Han, Taiji Suzuki, Arya Mazumdar)
NeurIPS 2025.

4. **Models of Heavy-Tailed Mechanistic Universality.**
(with Liam Hodgkinson and Michael W. Mahoney)
ICML 2025.

5. **Universality of kernel random matrices and kernel regression in the quadratic regime.**
(with Parthe Pandit and Yizhe Zhu)
JMLR to appear.

6. **Nonlinear spiked covariance matrices and signal propagation in deep neural networks.**
(with Denny Wu and Zhou Fan)
37th Annual Conference on Learning Theory.

7. **Optimal Exact Recovery in Semi-Supervised Learning: A Study of Spectral Methods and Graph Convolutional Networks.**
(with Haixiao Wang)
ICML 2024.

8. **High-Dimensional Asymptotics of Feature Learning in the Early Phase of Neural Network Training.**
(with Jimmy Ba, Murat A. Erdogdu, Taiji Suzuki, Denny Wu, and Greg Yang)

9. **Faithful and Efficient Explanations for Neural Networks via Neural Tangent Kernel Surrogate Models.**
(with Andrew Engel, Natalie S. Frank, Ioana Dumitriu, Sutanay Choudhury, Anand Sarwate, and Tony Chiang)
The Twelfth International Conference on Learning Representations (ICLR 2024). **Spotlight**

10. **Learning in the Presence of Low-dimensional Structure: A Spiked Random Matrix Perspective.**
(with Jimmy Ba, Murat A. Erdogdu, Taiji Suzuki, and Denny Wu)
Advances in Neural Information Processing Systems 36 (2023).

11. **Spectral evolution and invariance in linear-width neural networks.**
(with Andrew Engel, Anand Sarwate, Ioana Dumitriu, and Tony Chiang)
Advances in Neural Information Processing Systems 36 (2023).

12. **Deformed semicircle law and concentration of nonlinear random matrices for ultra-wide neural networks.**
(with Yizhe Zhu)
The Annals of Applied Probability, 34(2), pp.1896-1947.

13. **Overparameterized random feature regression with nearly orthogonal data.**
(with Yizhe Zhu)
In International Conference on Artificial Intelligence and Statistics (AISTATS), pp. 8463-8493. PMLR, 2023.

14. **High-dimensional Asymptotics of Feature Learning: How One Gradient Step Improves the Representation.**
(with Jimmy Ba, Murat A. Erdogdu, Taiji Suzuki, Denny Wu, and Greg Yang)
Advances in Neural Information Processing Systems 35 (2022): 37932-37946.

15. **Tree convolution for probability distributions with unbounded support.**
(with Ethan Davis and David Jekel)
Latin American Journal of Probability and Mathematical Statistics (ALEA) 18.2 (2021), pp. 1585-1623.

16. **Principal components in linear mixed models with general bulk.**
(with Zhou Fan and Yi Sun)
The Annals of Statistics, 49.3 (2021), pp. 1489-1513.

17. **Spectra of the Conjugate Kernel and Neural Tangent Kernel for linear-width neural networks.**
(with Zhou Fan)
Advances in Neural Information Processing Systems 33 (2020): 7710-7721. **Oral Presentation**

18. **Higher variations for free Lévy processes.**
(with Michael Anshelevich)
Studia Math. 252 (2020), pp. 49-81.

INTERNSHIP EXPERIENCE

Research Internship *06/2021- 09/2022*

Pacific Northwest National Laboratory, Advisor: Tony Chiang.

Deep learning research and software development.

Research Internship *07/2016-08/2016*

Academy of Mathematics and Systems Science, Chinese Academy of Sciences, Advisor: Prof. Feimin Huang.

TEACHING EXPERIENCE

Teaching Assistant, Department of Mathematics, UCSD *09/2019-present*

MATH 3C Pre-Calculus
MATH 10B&C Calculus
MATH 170A Numerical Linear Algebra
MATH 180A Introduction to Probability
MATH 280B&C Graduate Probability Theory

Teaching Assistant, Department of Mathematics, Texas A&M University *01/2017-07/2019*

MATH 308 Differential Equations
MATH 411 Mathematical Probability
MATH 220 Foundation of Mathematics
MATH 467 Modern Geometry
MATH 152&251 Engineering Mathematics

HONORS AND AWARDS

2025	SLMath Postdoctoral Fellowship, USA
2023	Scholar Award of NeurIPS 2023, USA
2019	James B. Ax Fellowship, UCSD, USA
2017	Graduate Fellowship in Department of Mathematics, TAMU, USA
2016, 2017	Study Abroad Scholarships, Beihang University, China
2016	Meritorious Winner of MCM/ICM Contest, USA
2015, 2016	Hua Luogeng Scholarships, Academy of Mathematics and Systems Science, Chinese Academy of Sciences
2014, 2015	Huatong Scholarships, Beihang University, China
2014, 2015	Scholarships of Academic Performance, Beihang University, China
2014	First Prize in College Students Physics Contest in Beijing, China

SELECTED TALKS AND INVITED PRESENTATIONS

04/2025	SLMath probability seminar at Berkeley.
02/2025	ITA workshop at San Diego.
09/2024	Probability seminar at UC Berkeley.
06/2024	DIMACS Workshop at Rutgers University.
04/2024	Southern California Applied Mathematics Symposium.
04/2024	LU-UMN Joint Probability Seminar.
11/2023	5th Annual Conference on the Mathematical Theory of Deep Learning (DeepMath).
08/2023	IAIFI Summer Workshop at Northeastern University.
07/2023	HiLD: High-dimensional Learning Dynamics Workshop, ICML Workshop 2023.
05/2023	Summer School on Random Matrix Theory and Its Applications at OSU.
04/2023	Southern California Applied Mathematics Symposium (SOCAMS 2023).
09/2022	SIAM Conference on Mathematics of Data Science (MDS22).
06/2022	RMMC Summer School at University of Wyoming.
03/2022	Combinatorics and Probability Seminar at UC Irvine.
12/2021	Frontier Probability Days 2021, at Las Vegas.
09/2021	Universality and Integrability in Random Matrix Theory and Interacting Particle Systems Workshop, at MSRI (virtual).
03/2021	Machine Learning Seminar, at Pacific Northwest National Laboratory (virtual).
12/2020	Neural Information Processing Systems (NeurIPS) virtual **oral presentation**.

MENTORSHIP EXPERIENCE

Mentor at the Cohort Program, School of Physical Sciences, UCSD *09/2023-06/2024*

Provide first-year undergraduate students in STEM with the essential tools, strategies, and support necessary to excel academically, develop professionally, explore research and internship opportunities, and share experiences of graduate school applications.

Mentor at Department of Mathematics, UCSD *9/2021-06/2022*

Mentor at Math Department, Beihang University *10/2014-07/2015*

PROFESSIONAL SERVICE

Journal Reviewer: JMLR, Annals of Statistics, Canadian Journal of Mathematics, Transactions on Machine Learning Research, Mathematical Programming, SIAM Data Science, Electronic Journal of Probability.

Conference Reviewer: AISTATS '22, AISTATS '23, NeurIPS '23, ICLR '24, AISTATS '24, ICML '24, NeurIPS '24, AISTATS '25.

Workshop Organizer: JMM 2025, Special Session on Mathematics of Deep Learning: A High-Dimensional Probability Perspective.

SKILLS

Language	Chinese (Native), English (Fluent)
Software	Python, PyTorch, JAX, MATLAB, LaTeX, TensorFlow