Benjamin Jiahong Zhang

Current Position
Postdoctoral Research Associate
Division of Applied Mathematics, Brown University

Contact Information
Division of Applied Mathematics
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Education

Massachusetts Institute of Technology, Cambridge, MA 02/2022

PhD, Computational Science and Engineering

- Thesis: *Efficient sampling methods of, by, and for stochastic dynamical systems*
- Committee: Y. Marzouk (Chair and advisor), T. Sahai, T. Sapsis, K. Spiliopoulos

SM, Aeronautics and Astronautics 06/2017

- Thesis: *A Coupling Approach to Rare Event Simulation via Dynamic Importance Sampling*
- Advisor: Y. Marzouk

University of California, Berkeley, Berkeley, CA 05/2015

BS, Engineering Physics

BA, Applied Mathematics, Concentration in Numerical Analysis

- Highest Honors in Applied Mathematics, Distinction in General Scholarship
- Thesis: *A Computational Study of Seizure Attenuation via Anderson Localization*
- Advisors: M.-R. Alam (Mechanical Engineering), P.-O. Persson (Mathematics)

Research Interests
Mathematics of machine learning, mathematics of generative modeling, mathematical control theory, rare event simulation, Bayesian computation

Research Experience

Division of Applied Mathematics, Brown University Providence, RI

Postdoctoral Research Associate 08/2024 - Present
Continuation of AFOSR postdoc. Mentors: Paul Dupuis, Markos Katsoulakis, Luc Rey-Bellet

Department of Mathematics & Statistics, UMass Amherst Amherst, MA

Postdoctoral Research Associate 09/2022 - 07/2024
AFOSR postdoc. Mentors: Markos Katsoulakis, Luc Rey-Bellet, Paul Dupuis

Department of Aeronautics and Astronautics, MIT Cambridge, MA

Postdoctoral associate 01/2022 - 08/2022

Research assistant 09/2015 - 01/2022
Supervised by Professor Youssef Marzouk in the Uncertainty Quantification group.

Department of Mechanical Engineering, UC Berkeley Berkeley, CA

Undergraduate research assistant 09/2013 - 08/2015
Supervised by Professor Reza Alam.

Teaching experience

Division of Applied Mathematics, Brown University Providence, RI

Co-instructor 09/2024-12/2024
Senior seminar: Introduction to Mathematical Machine Learning (APMA 1930Z).

Department of Mathematics and Statistics, UMass Amherst Amherst, MA

Lecturer 01/2024 - 05/2024
Designed and delivered new course on Mathematical Machine Learning (MATH 590STA).

Department of Aeronautics and Astronautics, MIT Cambridge, MA

Course developer 12/2019 - 04/2020
Designed and co-wrote curriculum for MIT xPro online course on Modeling, Simulation, and Machine learning for working professionals.

Teaching assistant 01/2019 - 05/2019
Undergraduate probability & statistics for aerospace engineers (16.09). Awarded best teaching assistant award by the students.

Course developer and co-instructor Spring 2018, 2019
Designed curriculum and co-taught course for 16.S685 "A hands-on introduction to computational engineering," an introductory course targeted at first and second year undergraduates.

Seminar XL instructor 09/2018 - 05/2019
Lead small 18.03 (Differential Equations) study groups for first year URM students. Facilitated by the MIT Office of Minority education.

Teaching assistant and grader 09/2018 - 12/2018
Graduate class on numerical methods for stochastic processes and inference (16.940).

Subject Design Certificate Program 07/2020
From the MIT Teaching and Learning lab.

Department of Mathematics, UC Berkeley Berkeley, CA

Teaching assistant 01/2015 - 05/2015
Second semester introductory calculus (Math 1B).

Professional experience

United Technologies Research Center, UTC (Now Raytheon) Berkeley, CA

Research intern 06/2017 - 09/2017
Researched queuing systems for modeling human operators. Also investigated using quantum computing for optimization.

Publications

Journal articles

13. **B. Zhang**, Y. Marzouk, and K. Spiliopoulos. Transport map unadjusted Langevin algorithms. *Foundations of Data Science, accepted. arXiv:2302.07227*, 2024
12. **B. Zhang**, Y. Marzouk, and K. Spiliopoulos. Geometry-informed irreversible perturbations for accelerated convergence of Langevin dynamics. *Statistics and Computing*, 32(5):78, 2022
11. **B. Zhang**, T. Sahai, and Y. Marzouk. A Koopman framework for rare event simulation in stochastic differential equations. *Journal of Computational Physics*, 456:111025, 2022
10. **B. Zhang**, M. Chamanzar, and M.-R. Alam. Suppression of epileptic seizures via anderson localization. *Journal of The Royal Society Interface*, 14(127):20160872, 2017

Peer-reviewed conference proceedings

9. N. Mimikos-Stamatopoulos, **B. Zhang**, and M. Katsoulakis. Score-based generative models are provably robust: an uncertainty quantification perspective. *To appear, NeurIPS 2024*, 2024

Conference proceedings

8. **B. Zhang**, T. Sahai, and Y. Marzouk. Sampling via controlled stochastic dynamical systems. In *I (Still) Can't Believe It's Not Better! NeurIPS 2021 Workshop*
7. **B. Zhang**, Y. Marzouk, B.-Y. Min, and T. Sahai. Rare event simulation of a rotorcraft system. In *2018 AIAA Non-Deterministic Approaches Conference*, 2018

Preprints

6. Z. Chen, M. Katouslakis, and **B. Zhang**. Equivariant score-based generative models provably learn distributions with symmetries efficiently. *arXiv preprint arXiv:2410.01244*, 2024
5. H. Gu, M. Katsoulakis, L Rey-Bellet, and **B. Zhang**. Combining Wasserstein-1 and Wasserstein-2 proximals: robust manifold learning via well-posed generative flows. *arXiv preprint arXiv:2407.11901*, 2024

4. J. Birrell, M. Katsoulakis, L. Rey-Bellet, **B. Zhang**, and W. Zhu. Nonlinear denoising score matching for enhanced learning of structured distributions. *arXiv preprint arXiv:2405.15625*, 2024
3. **B. Zhang**, S. Liu, W. Li, M. Katsoulakis, and S. Osher. Wasserstein proximal operators describe score-based generative models and resolve memorization. *arXiv preprint arXiv:2402.06162*, 2024
2. **B. Zhang** and M. Katsoulakis. A mean-field games laboratory for generative modeling. *arXiv preprint arXiv:2304.13534*, 2023
1. **B. Zhang**, T. Sahai, and Y. Marzouk. Computing eigenfunctions of the multidimensional Ornstein-Uhlenbeck operator. *arXiv preprint arXiv:2110.09229*, 2021

Mentoring

Master's theses advised:

- Joshua W. (MIT AeroAstro) 2021 – 2022
  Thesis: Rare event simulation via tensor-based approaches to stochastic optimal control

Undergraduate research students advised:

- Emily C. (UMass Amherst REU) 2024
- Hoang Son P. (UMass Amherst REU) 2024
- Ben B. (UMass Amherst REU, Honors Thesis) 2023 – 2024
- Alex R. (UMass Amherst REU) 2023
- Joshua W. (MIT UROP, SuperUROP) 2019 – 2021
- Karolina P. (MIT UROP) 2018 – 2019

Awards

SFB 1294 Data Assmiliation Short-term Visiting Research Fellowship 2022

Mathworks Engineering Fellowship 2019

AIAA Teaching Assistant Award (Best TA selected by the MIT-AIAA Student chapter) 2019

NSF Graduate Research Fellowships Program Honorable Mention 2015, 2016

Phi Beta Kappa 2015

Summer Undergraduate Research Fellowship (SURF L&S) 2014

Tau Beta Pi Engineering Honor Society 2013

Matsui Center Cal-in-Sacramento Fellowship 2013

Service

Organizer of the *Learning Learning Student Seminar* 2023 – 2024

Organizer of the Uncertainty Quantification Reading Group 2019 – 2021

ACDL Undergraduate Research Opportunity Coordinator (UROP) 2017 – 2021

Association of Computational Science and Engineering Students Co-President 2017 – 2018

- Organized the 2018 and 2019 MIT Center for Computational Engineering annual symposium

Ad hoc paper reviewer: *SIAM Journal on Mathematics of Data Science*; *SIAM/ASA Journal on Uncertainty Quantification*; *Probabilistic Engineering Mechanics*; *Stochastics and Partial Differential Equations*; *SIAM Journal on Scientific Computing* ; *Physica D: Nonlinear Phenomena*; *Symposium on Advances in Approximate Bayesian Inference, ICML 2023, 2024, 2025*; *I Can't Believe It's Not Better Workshop, NeurIPS 2023*; *Deep Generative Models for Health Workshop, NeurIPS 2023*

Minisymposium organization:

- JMM 2025, SIAM Special Session: *Mathematical perspectives of generative modeling* (10 talks)
- SIAM MDS 2024: *Foundations of Structure-exploiting Flow-based Generative Models* (4 talks)
- SIAM UQ 2024: *Optimal Transport for Uncertainty Quantification* (4 talks)
- SIAM UQ 2022: *Data-Driven Approaches to Rare and Extreme Events* (8 talks)
- SIAM CSE 2021: *Computational Dynamics meets Computational Statistics* (10 talks)
- SIAM CSE 2019: *Advances in Rare Event Simulation for Dynamical Systems* (8 talks)

Invited Talks & Seminars

17. **B. Zhang**. Probabilistic operator learning: generative modeling and uncertainty quantification for in-context operator learning. Sampling, Inference, and Data-Driven Physical Modeling in Scientific Machine Learning, Institute for Pure and Applied Mathematics (IPAM), UCLA, Jul 14-18, 2025.
16. **B. Zhang**. A mean-field games laboratory for analysis and innovation in generative machine learning. ACMS Colloquium, Department of Applied and Computational Mathematics and Statistics, University of Notre Dame, December 9, 2024.
15. **B. Zhang**. A mean-field games laboratory for analysis and innovation in generative machine learning. CMOR Research Colloquium, Department of Computational Applied Mathematics and Operations Research, Rice University, December 2, 2024.
14. **B. Zhang**. A primer on applied stochastic differential equations. Random Dynamical Systems with Applications in Biology Workshop, NSF-Simons Institute for Mathematics and Theory in Biology, Nov 7, 2024.
13. **B. Zhang** and M. Katsoulakis. A mean-field games laboratory for generative modeling. Probability Seminar, Division of Applied Mathematics, Brown University, December 12, 2023.
12. **B. Zhang** and M. Katsoulakis. A mean-field games laboratory for generative modeling. NYU Shanghai Frontiers Science Center of Artificial Intelligence and Deep Learning, November 16, 2023.
11. **B. Zhang**. A mean-field games laboratory for generative modeling. Computational and Data-enabled Science Seminar, Emory University, October 26, 2023.
10. **B. Zhang** and M. Katsoulakis. A mean-field games laboratory for generative modeling. Webinar on Mean-field games and machine learning, October 24, 2023.
9. **B. Zhang** and M. Katsoulakis. A mean-field games laboratory for generative modeling. Level Set Collective, UC Los Angeles, Los Angeles, CA, June 26, 2023.
8. **B. Zhang** and M. Katsoulakis. A mean-field games laboratory for generative modeling. SRI International, Menlo Park, CA, June 7, 2023.
7. **B. Zhang**. What is Bayesian computation? The What is... Graduate Seminar (TWIGS). UMass Amherst, Amherst MA, November 21, 2022.
6. **B. Zhang**, K. Spiliopoulos, and Y. Marzouk. Novel perturbations for accelerating Langevin sampling. Applied Mathematics and Computation Seminar, UMass Amherst, Amherst MA, October 18, 2022.
5. **B. Zhang**, K. Spiliopoulos, and Y. Marzouk. Transport map unadjusted Langevin algorithm. Aerospace Computational Design Laboratory Seminar, MIT, Cambridge MA, April 1, 2022.
4. **B. Zhang**, T. Sahai, and Y. Marzouk. A Koopman framework for sampling in stochastic dynamical systems. LIDS and Stats Tea Talk, MIT, Cambridge, MA, April 8, 2020.
3. **B. Zhang**, T. Sahai, and Y. Marzouk. A Koopman framework for sampling in stochastic dynamical systems. Aerospace Computational Design Laboratory Seminar, MIT, Cambridge MA, December 6, 2019.
2. **B. Zhang**, T. Sahai, and Y. Marzouk. Sampling methods for stochastic dynamical systems using Koopman eigenfunctions. United Technologies Research Center, Berkeley, CA, September 25, 2019.
1. N. Chandramoorthy, and **B. Zhang**. Koopman operators and the problems related to their computation. Aerospace Computational Design Laboratory Seminar, MIT, Cambridge MA, December 7, 2018.

Conference & Workshop Presentations

21. **B. Zhang** and P. Dupuis. Ergodic control via interacting particle systems and generative modeling, 2025. SIAM Conference on Computational Science and Engineering, Fort Worth, TX.
20. **B. Zhang** and M Katsoulakis. A mean-field games laboratory for generative modeling (talk and poster), 2024. SIAM Conference on Mathematics of Data Science, Atlanta, GA.
19. **B. Zhang**, S. Liu, W. Li, M. Katsoulakis, and S. Osher. Wasserstein proximals describe score-based generative models and resolve memorization (poster), 2024. ICERM workshop on Robust Optimization and Simulation of Complex Stochastic Systems, Providence, RI.

18. **B. Zhang** and M Katsoulakis. A mean-field games laboratory for generative modeling, 2024. SIAM Conference on Uncertainty Quantification, Trieste, Italy.
17. **B. Zhang** and M. Katsoulakis. A mean-field games laboratory for generative modeling (poster), 2023. ICERM workshop on Optimal transport in Data Science, Providence, RI. (**Travel grant awarded**)
16. **B. Zhang**, K. Spiliopoulos, and Y. Marzouk. Transport map unadjusted Langevin algorithm: analysis and connections, 2022. SIAM Conference on Mathematics of Data Science, San Diego, CA.
15. **B. Zhang**, Q. Long, J. White, T. Sahai, and Y. Marzouk. Data-driven rare event simulation for stochastic dynamical systems: A Koopman operator approach, 2022. SIAM Conference on Uncertainty Quantification, Atlanta, GA.
14. **B. Zhang**, T. Sahai, and Y. Marzouk. Sampling via controlled stochastic dynamical systems (poster), 2021. I Can't Believe It's Not Better Workshop, Neural Information Processing Systems Conference.
13. **B. Zhang**, J. White, T. Sahai, and Y. Marzouk. Rare event simulation for linear SDEs via multilevel splitting, 2021. SIAM Conference on Applications of Dynamical Systems, Portland, OR.
12. **B. Zhang**, T. Sahai, and Y. Marzouk. Sampling via controlled stochastic dynamical systems, 2021. SIAM Conference on Computational Science and Engineering, Austin, TX.
11. **B. Zhang**, T. Sahai, and Y. Marzouk. Sampling via controlled stochastic dynamical systems, 2020. Second symposium on machine learning and dynamical systems, Fields Institute.
10. **B. Zhang**, T. Sahai, and Y. Marzouk. Importance sampling for linear SDEs using eigenfunctions of the Ornstein-Uhlenbeck operator (poster), 2019. ICERM workshop on Mathematical Optimization of Systems Impacted by Rare, High-Impact Random Events, Providence, RI. (**Travel grant awarded**)
9. **B. Zhang**, T. Sahai, and Y. Marzouk. Rare event simulation in nonlinear dynamical systems via the Koopman operator, 2019. International Congress on Industrial and Applied Mathematics, Valencia, Spain.
8. **B. Zhang**, T. Sahai, and Y. Marzouk. Towards a generalized theory of rare event simulation for linear stochastic differential equations, 2019. SIAM Conference on Applications of Dynamical Systems, Snowbird, UT.
7. Q. Long, **B. Zhang**, Y. Marzouk, A. Gorodetsky, and T. Sahai. Tensor decomposition-based splitting methods for rare event simulation, 2019. SIAM Conference on Applications of Dynamical Systems, Snowbird, UT.
6. **B. Zhang**, T. Sahai, and Y. Marzouk. Efficient simulation of rare events in stochastic differential equations, 2019. SIAM Conference on Computational Science and Engineering, Spokane, WA.
5. **B. Zhang**, T. Sahai, and Y. Marzouk. Rare event simulation for dynamical systems in the presence of an attractor, 2018. SIAM Annual Meeting, Portland, OR.
4. **B. Zhang** and T. Sahai. A probabilistic analysis and rare event study of a dynamical queue for modeling human operators, 2018. SIAM Conference on Uncertainty Quantification, Garden Grove, CA.
3. **B. Zhang**, Y. Marzouk, B.-Y. Min, and T. Sahai. Rare event simulation of a rotorcraft system, 2018. AIAA Scitech Forum Non-deterministic Approaches Conference, Kissimmee, FL.
2. **B. Zhang**, Y. Marzouk, B.-Y. Min, and T. Sahai. Rare event simulation via dynamic importance sampling and measure transport (poster), 2017. USACM Thematic Workshop on Uncertainty Quantification and Data-Driven Modeling, Austin, TX. (**Travel grant awarded**)
1. **B. Zhang**, Y. Marzouk, and T. Sahai. Scalable methods for rare event simulation in rotorcraft systems, 2017. SIAM Conference on Computational Science and Engineering, Atlanta, GA.

Workshops attended

11. Sampling, Inference, and Data-Driven Physical Modeling in Scientific Machine Learning, Institute for Pure and Applied Mathematics (IPAM), UCLA, Jul 14-18, 2025. (**Invited speaker**)
10. Random Dynamical Systems, with Applications in Biology, NSF-Simons National Institute for Mathematics and Theory in Biology, Nov 4-8, 2024. (**Invited speaker**)
9. Robust Optimization and Simulation of Complex Stochastic Systems, Institute for Computational and Experimental Research in Mathematics (ICERM), Brown University, Sep 13-15, 2024.
8. Optimal Transport in Data Science, Institute for Computational and Experimental Research in Mathematics (ICERM), Brown University, May 8-12, 2023.
7. Data Assimilation – Mathematical Foundation and Applications, Mathematisches Forschungsinstitut Oberwolfach (MFO, Oberwolfach Research Institute for Mathematics) , February 20-26, 2022.
6. "I Can't Believe It's Not Better" Workshop at the Neural Information Processing Systems Conference (NeurIPS) 2021, held virtually, December 13, 2021.
5. Second Symposium on Machine Learning and Dynamical Systems, Fields Institute for Research in Mathematical Sciences, University of Toronto, September 21-29, 2020.
4. Mathematical Optimization of Systems Impacted by Rare, High-Impact, Random Events, Institute for Computational and Experimental Research in Mathematics (ICERM), Brown University, June 24-28, 2019.
3. Optimal Transport: Numerical Methods and Applications, Lake Como School of Advanced Studies, May 7-11, 2018.
2. USACM Workshop on Uncertainty Quantification and Data-Driven Modeling, Austin TX, March 23-24, 2017.
1. Summer School in Monte Carlo Methods for Rare Events, Division of Applied Mathematics, Brown University, June 13-17, 2016.