George Stepaniants

gstepan@caltech.edu | georgestepaniants@gmail.com | https://georgestepaniants.com

I develop methods to learn mathematical and physical laws from simulated and experimental data, using numerical analysis, mechanics, statistics, and machine learning to design approaches that succeed in data-limited regimes and embody the right inductive biases for scientific data. My teaching philosophy is inspired by my research, showing students how to discover mathematical ideas in field-specific literature, translate them into well-posed theories, and bring these theories to life as numerical algorithms and reproducible code.

Research Areas: Applied and Computational Mathematics, Mechanics of Materials, Fluid Dynamics, Biophysics, Scientific Computing, Numerical Analysis, Statistical Theory and Methods, High-Dimensional Statistics, Machine Learning, Scientific ML

Employment

Sep 2024 - Present — **California Institute of Technology (NSF Postdoctoral Scholar)**
NSF Mathematical Sciences Postdoctoral Research Fellow (MSPRF)
Department of Computing and Mathematical Sciences (CMS)
Postdoctoral Advisor: Andrew M. Stuart

Education

Sep 2019 - Jun 2024 — **Massachusetts Institute of Technology (PhD)**
GPA: 4.9/5.0
Department of Mathematics and Institute for Data, Systems, and Society (IDSS)
PhD Advisors: Philippe Rigollet and Jörn Dunkel
Graduate Thesis: *Inference from limited observations in statistical, dynamical, and functional problems*

Sep 2015 - Jun 2019 — **University of Washington (BSc)**
GPA: 3.87/4.00
Department of Mathematics and Department of Computer Science (double major)
Undergraduate Research Advisors: Nathan Kutz and Bing Brunton
Research Topic: *Inferring causal networks of dynamical systems through transient dynamics and perturbation*

Academic Awards

NSF Mathematical Sciences Postdoctoral Research Fellowship (MSPRF 2402074)	Sep 2024 – Current
IMS Lawrence D. Brown Ph.D. Student Award Recipient (3 recip. nationwide)	Sep 2024
NSF Graduate Research Fellowship (GRFP 1745302)	Jun 2019 – Jun 2024
SIAM Student Travel Award	Dec 2023
Calouste Gulbenkian Foundation Short Term Conference and Travel Grant	Jun 2023
MIT Presidential Fellowship	Sep 2019 – Jun 2020
Phi Beta Kappa Honors Society Member	Jun 2019
Mary Gates Research Scholarship (merit-based)	Jun 2019
University of Washington Dean's List	Sep 2015 – Jun 2019
Early acceptance to University of Washington at age 16 (UW Academy)	Sep 2015

Publications

Please see also my Google Scholar and ORCID ID. († alphabetical order, * joint first author)

Thesis

[T1] George Stepaniants. "Inference from Limited Observations in Statistical, Dynamical, and Functional Problems." *Massachusetts Institute of Technology* (2024).

Manuscripts in Review

[R1] 📎 David Darrow and † George Stepaniants. "A Spectral Theory of Scalar Volterra Equations." *arXiv preprint arXiv:2503.06957* (2025). † Authors listed alphabetically.

[R2] 📎 Kaushik Bhattacharya, Lianghao Cao, † George Stepaniants, Andrew Stuart, and Margaret Trautner. "Learning Memory and Material Dependent Constitutive Laws." *arXiv preprint arXiv:2502.05463* (2025). † Authors listed alphabetically.

Journal Articles

[J1] 📎 Yanjun Han, Philippe Rigollet, and † George Stepaniants. "Covariance alignment: from maximum likelihood estimation to Gromov-Wasserstein." *SIAM Journal on Mathematics of Data Science* 7.3 (2025): 1491-1513. † Authors listed alphabetically.

[J2] 📎 George Stepaniants*, Alasdair D. Hastewell*, Dominic J. Skinner, Jan F. Totz, and Jörn Dunkel. "Discovering dynamics and parameters of nonlinear oscillatory and chaotic systems from partial observations." *Phys. Rev. Res.* 6, 043062 (2024). * Equal contribution.

[J3] 📎 Marie Breeur*, George Stepaniants*, Pekka Keski-Rahkonen, Philippe Rigollet, and Vivian Viallon. "Optimal transport for automatic alignment of untargeted metabolomic data." *eLife 12:RP91597* (2024). * Equal contribution.

[J4] 📎 George Stepaniants. "Learning partial differential equations in reproducing kernel Hilbert spaces." *Journal of Machine Learning Research* 24.86 (2023): 1-72.

[J5] 📎 George Stepaniants, Bingni W. Brunton, and J. Nathan Kutz. "Inferring causal networks of dynamical systems through transient dynamics and perturbation." *Physical Review E* 102.4 (2020): 042309.

Conference Proceedings

[C1] 📎 Enric Boix-Adserà, Hannah Lawrence, George Stepaniants, and Philippe Rigollet. "GULP: a prediction-based metric between representations." *Advances in Neural Information Processing Systems* (2022).

[C2] 📎 Sinho Chewi, Julien Clancy, Thibaut Le Gouic, Philippe Rigollet, † George Stepaniants, and Austin Stromme. "Fast and smooth interpolation on Wasserstein space." *International Conference on Artificial Intelligence and Statistics*. PMLR (2021). † Authors listed alphabetically.

In Preparation

[P1] George Stepaniants*, David Darrow*, and Chris Camaño. SIEVE: Spectral integral transforms, poly-exponential approximants, and Volterra equations. * Equal contribution.

Talks and Presentations

Organized Symposia

- "Minisymposium on Data-Driven Methods for Multiscale Modeling and Homogenization", SIAM Conference on Computational Science and Engineering, Fort Worth, March 2025
- "Minisymposium on Data-Driven Learning of Dynamical Systems from Partial Observations", SIAM Conference on Mathematics of Data Science, Atlanta, October 2024

Invited Talks

- "Volterra Integral Equations and Memory Dependent Constitutive Laws", UC Irvine Applied & Computational Math Seminar, Irvine, October 2025
- "Learning Memory and Material Dependent Constitutive Laws", Surrogates and Dimension Reduction in Scientific Machine Learning, Manchester University, September 2025
- "Alignment of Untargeted Data through their Covariances: A Novel Perspective on a Classical Tool in Optimal Transport", Joint Statistics Meeting, Nashville, August 2025 **(One of 3 PhD students selected for the prestigious IMS Lawrence D Brown PhD Student Award)** 📎

- "A Spectral Theory of Volterra Equations: Applications to Learning of Material Laws", Efficient and Reliable Deep Learning Methods and their Scientific Applications, **Banff BIRS Centre**, June 2025
- "Learning Dynamics of Hidden Variables in Multiscale Viscoelastic Materials", SIAM Conference on Applications of Dynamical Systems, Denver, May 2025
- "A Spectral Theory of Scalar Volterra Equations", Dartmouth Applied & Computational Math Seminar, Dartmouth, March 2025
- "A Spectral Theory of Scalar Volterra Equations", MIT Applied Math Physical Mathematics Seminar, Cambridge, March 2025
- "Learning Memory and Material Dependent Constitutive Laws", Differential Equations for Data Science, Kyoto University, February 2025
- "Discovering dynamics and parameters of nonlinear oscillatory and chaotic systems from partial observations", Fourth Symposium on Machine Learning and Dynamical Systems, **Fields Institute**, July 2024
- "Covariance Alignment with Optimal Transport", Yale Applied Mathematics Seminar, New Haven, April 2024
- "Gromov-Wasserstein Theory and Application to Metabolomics", SIAM Conference on Uncertainty Quantification, Trieste, Italy, February 2024
- "Gromov-Wasserstein Theory and Application to Metabolomics", Statistics and Learning Theory Summer School, Tsaghkadzor, Armenia, July 2023 **(One of 7 invited speakers)**
- "Optimal transport for automatic alignment of untargeted metabolomic data", Harvard Applied Math Graduate Student Seminar, Cambridge, March 2023
- "Learning PDEs in a Reproducing Kernel Hilbert Space", SIAM Conference on Mathematics of Data Science, San Diego, September 2022
- "Learning PDEs in a Reproducing Kernel Hilbert Space", Meeting on Mathematical Statistics, **CIRM**, Marseille, France, December 2021 **(Only 3 graduate student speakers invited)**

Contributed Talks

- "Discovering dynamics and parameters of nonlinear oscillatory and chaotic systems from partial observations", Dynamics Days, UC Davis, January 2024
- "Learning and predicting complex systems dynamics from single-variable observations", APS March Meeting, Chicago, March 2022
- "Learning PDEs in a Reproducing Kernel Hilbert Space", LIDS Stats & Tea, MIT, December 2021
- "Inferring causal networks of dynamical systems through transient dynamics and perturbation", Econometrics Lunch, MIT, December 2021
- "Fusion of Genetically Incompatible Fungal Cells", UCLA Computational and Applied Math REU Presentation, IPAM, August 2018
- "Quantifying Rupture Risk of Brain Anuerysms", MATDAT18: NSF Materials and Data Science Hackathon, Alexandria, June 2018
- "Hyperparameter Selection", AI2 Research Internship Final Presentation, Seattle, August 2017
- "Beaker Experimentation Platform", AI2 Research Internship Midterm Presentation, Seattle, August 2017
- "Image Analysis in Parkinson's Research", Pfizer Research Internship Final Presentation, Cambridge, August 2016

Poster Presentations

- "Covariance alignment: from maximum-likelihood estimation to Gromov-Wasserstein", Cornell ORIE Young Researchers Workshop, Cornell, October 2023
- "Inferring causal networks of dynamical systems through transient dynamics and perturbation", Undergraduate Research Symposium, UW, June 2019

Teaching Experience

(ACM 270) California Institute of Technology – Instructor of Record Spring 2025

Designer and Instructor of New Course for Data-Driven Modeling of Dynamical Systems

Two weekly 1.5 hour classes with 30+ students, with final presentations and projects, unifying topics in system identification, sparse model inference, Koopman theory, adjoint methods, data assimilation, and scientific ML. Turning class content and lectures into a class text.

(MIT 18.032) Massachusetts Institute of Technology – Teaching Assistant Spring 2022

Teaching Assistant for Differential Equations (theory focused)

Two weekly 1 hour recitations with 16 students, including grading of homeworks/finals and proctoring final exams. Covering existence and uniqueness theory (Cauchy-Lipschitz Theorem, Picard iterations), control and comparison of solutions, maximal solutions, Grönwall's Lemma, multivariable ODEs, and fixed point stability.

(MIT 18.600) Massachusetts Institute of Technology – Teaching Assistant Fall 2021

Teaching Assistant for Introduction to Probability

Two weekly 1 hour recitations with 40 students, including grading of homeworks and finals. Covering probability spaces, random variables, classes of distributions, Bayes theorem, Chebyshev inequality, law of large numbers, and central limit theorems.

Mentoring Experience

(SURF) California Institute of Technology Summer 2025

Undergraduate Research Mentor for Vladislav Syntko (Maastricht University, Netherlands)

A Signature-Based Approach for System Identification and Control: *Applications and theory for signature transform methods in open-loop control of dynamical systems.*

(WAVE) California Institute of Technology Summer 2025

Undergraduate Research Mentor for Owen Tolbert (University of Maryland Baltimore County)

A Study of Network Inference Methods: *Information-theoretic and deep learning methods for inference of networked dynamical systems.*

(MCM) California Institute of Technology Fall 2024

Trained three undergraduate Caltech teams for the Mathematical Competition in Modeling, coaching and solving practice problems over the course of several months

- (Honorable Mention) Gautham Kappaganthula, Constantin Cedillo-Vayson de Pradenne, Colin La
- (Successful Participant) Joseph Pieper, Sujay Champati, Dhruv Verma
- (Successful Participant) James Hou, Aman Burman, Abhiram Cherukupalli

(Mentor) California Institute of Technology Fall 2024

Undergraduate Research Mentor for Zixiang Zhou (University of Southern California)

Mentored research reading and project in data-driven dynamical systems inference algorithms based on the method of characteristics.

(SPUR+) Massachusetts Institute of Technology — Summer 2023 – Fall 2023

Undergraduate Research Mentor for Elaine Liu (Massachusetts Institute of Technology)

Modeling International Trade and Tariffs: *Study of large trade and tariffs dataset across 200 world countries, investigating the use of spectral and graph wavelet decompositions for analysis of temporal trade network data.*

(DRP) Massachusetts Institute of Technology — Summer 2023

Directed Reading Program with Loreta Arzumanyan and Joshua Curtis Kuffour (Massachusetts Institute of Technology)

Guided reading of two undergraduate students in graduate dynamical systems text "Stability, Instability and Chaos" by Paul Glendinning over the course of the summer. Prepared students to present their knowledge of the text in a final presentation at the end of summer.

(Mentor) Massachusetts Institute of Technology — Summer 2023

Undergraduate Research Mentor for Donald J Liveoak and Hanna Chen (Massachusetts Institute of Technology)

Guided research readings with two MIT undergraduates on optimal transport and adjoint methods for inference of stochastic dynamical systems and networked dynamical systems.

(UROP) Massachusetts Institute of Technology — Fall 2021 – Spring 2021

Undergrad Research Mentor for David Darrow (Massachusetts Institute of Technology)

Optimal Transport for Protein Folding: *Studying how optimal transport and Gromov-Wasserstein methods can be used to predict the three-dimensional structure of proteins.*

David Darrow awarded 2022 Churchill Scholarship

(Community Service) University of Washington

Math tutoring from K12 to college-level subjects	2015 – 2019
Teaching assistant at University of Washington Math Circle	2015 – 2016

Service and Leadership

1. Organizer of Caltech CMS Departmental CMX Seminar 2025 – 2026
2. Board Member of One World Seminar on Mathematics of Machine Learning 2025
3. Organizer of SURF/WAVE undergraduate research across three faculty at Caltech CMS 2025
4. Presenter on AI literacy and societal impact in LA and NY Armenian communities 2025
5. Organized panel on graduate school experience and research in Redmond Armenian community 2020
6. Founded and led Armenian Student Association at the University of Washington (ASAUW) 2015 – 2019
7. Competition judge at the University of Washington Math Olympiad 2015 – 2019

Professional Membership

- Institute of Mathematical Statistics (IMS) 2024 – Present
- Society for Industrial and Applied Mathematics (SIAM) 2020 – Present
- American Physical Society (APS) 2019 – Present

Internship and Research Experience

Jul 2018 - Aug 2018 | Computational and Applied Math **Research Experience for Undergrads (REU) at UCLA**

Undergraduate Researcher in Mycofluidics Lab

Worked in Professor Marcus Roper's lab on imaging of fungal cells in *Neurospora* and *Ashbya* fungal species. Collected data on nuclear division of these multinucleated cells using 3D imaging algorithms and performed data analysis on nuclear spacing and mixing within the cell. Discovered that genetically incompatible fungal strains fuse together when exposed to environmental stress. We are working on a paper that relies on the research findings and imaging algorithms I developed at UCLA.

Jun 2017 - Sep 2017 | Engineering Intern at **Allen Institute for Artificial Intelligence (AI2)**

Full Stack Development and Data Analysis/Visualization

Collaborated with researchers and built a system which optimized hyperparameter selection in various neural network experiments ran in the company. I was responsible for experiment design decisions in the company and execution of these experiments on a Google cluster. My platform significantly simplified the experimentation process and reduced the runtime by a factor of two.

Aug 2016 - Dec 2016 | Natural Language Processing Intern at **ABBYY**

Parser Accuracy Scoring

Compared ABBYY's parser efficiency and output to that of MaltParser. Created scripts in Java to read parser output from CoNLL-X data files and scored them using an unlabeled and labeled attachment score (UAS and LAS). Used Excel for visual and graphing purposes.

Jun 2016 - Aug 2016 | Image Analysis Intern at **Pfizer**

Imaging Algorithms for Automated Brain Slice Imaging

Worked in Neuroscience Pain Research Unit (NPRU) at Pfizer. Studied how various drugs help regenerate healthy cells damaged by neurodegenerative diseases, especially Parkinson's. Used image analysis algorithms, 3D Watershed Segmentation in particular, to quantify the percentage of regenerated healthy cells after treatment. My automated imaging pipeline was used by researchers to quantify hundreds of drug profiles and reduced the runtime of their image analysis code by 10 times.