

Justin Sirignano

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Academic Positions

Associate Professor, University of Oxford July 2020-
Mathematical Institute
Member of the Mathematical & Computational Finance Group
Member of the Data Science Group

Assistant Professor, University of Illinois at Urbana-Champaign 2016 - 2022
College of Engineering
Department of Industrial & Enterprise Systems Engineering
Coordinated Science Lab (Signals, Inference, and Networks group)

Chapman Fellow, Imperial College London 2015-2016
Department of Mathematics

Education

Stanford University, PhD 2010-2015

Princeton University, B.S.E. 2006-2010
Graduated *summa cum laude*
Elected to Phi Beta Kappa, Tau Beta Pi, and Sigma Xi

Research Interests

- Mathematical finance
- Mathematics of machine learning and deep learning
- Applications of machine learning to partial differential equation models

Research Publications

1. “Kernel Limit of Recurrent Neural Networks Trained on Ergodic Data Sequences” (with S. Lam and K. Spiliopoulos). arXiv:2308.14555, 2023.
2. “Global Convergence of Deep Galerkin and PINNs Methods for Solving Partial Differential Equations” (with D. Jiang and S. Cohen). arXiv:2305.06000, 2023.
3. “Continuous-time stochastic gradient descent for optimizing over the stationary distribution of stochastic differential equations” (with Z. Wang). arXiv: 2202.06637.
Accepted for publication at *Mathematical Finance*, 2023.
4. “Neural Q-learning for solving Elliptic PDEs” (with D. Jiang and S. Cohen).
Journal of Machine Learning Research, 2023.
5. “PDE-constrained Models with Neural Network Terms: Optimization and Global Convergence” (with J. MacArt and K. Spiliopoulos). arXiv:2105.08633.
Journal of Computational Physics, 2023.

6. “Deep Learning Closure Models for Large-Eddy Simulation of Flows around Bluff Bodies” (with J. MacArt).
Journal of Fluid Mechanics, 2023.
7. “Dynamic Deep Learning LES Closures: Online Optimization With Embedded DNS” (with J. MacArt).
arXiv: 2303.02338, 2023.
8. “Deep Learning Closure of the Navier-Stokes Equations for Transitional Flows” (with A. Nair, M. Panesi, and J. MacArt).
Accepted for publication at *AIAA Journal*, 2023.
9. “Entropy-stable Deep Learning for Navier–Stokes Predictions of Transitional-regime Flows” (with A. Nair, M. Panesi, and J. MacArt). Accepted to Proceedings of AIAA SciTech Forum, 2023.
10. “Online Adjoint Methods for Optimization of Partial Differential Equations” (with K. Spiliopoulos).
Applied Mathematics and Optimization, 85 (2), 2022.
11. “A Forward Propagation Algorithm for Online Optimization of Nonlinear Stochastic Differential Equations” (with Z. Wang). arXiv:2207.04496, 2022.
12. “Global Convergence of the ODE Limit for Online Actor-Critic Algorithms in Reinforcement Learning” (with Z. Wang). arXiv:2108.08655, 2021
Invited Revision at *Stochastic Systems*.
13. “Asymptotics of Reinforcement Learning with Neural Networks” (with K. Spiliopoulos).
Stochastic Systems, 2021.
14. “Deep Learning for Mortgage Risk” (with K. Giesecke and A. Sadhwani).
Journal of Financial Econometrics, 19 (2), 2021.
15. “Deep Learning Closure of the Navier–Stokes Equations for Transitional Flows” (with J. MacArt and M. Panesi). Accepted to Proceedings of AIAA SciTech Forum, 2022.
16. “Mean Field Analysis of Deep Neural Networks” (with K. Spiliopoulos).
Mathematics of Operations Research, 2021.
17. “Embedded training of neural-network sub-grid-scale turbulence models” (with J. Freund and J. MacArt).
Physical Review of Fluids, 6 (5), 2021.
18. “Mean Field Analysis of Neural Networks: A Law of Large Numbers” (with K. Spiliopoulos).
SIAM Journal on Applied Mathematics, 80 (2), 725-752, 2020.
19. “Mean Field Analysis of Neural Networks: A Central Limit Theorem” (with K. Spiliopoulos).
Stochastic Processes and their Applications, 130 (3), 1820-1852, 2020.
20. “Stochastic Gradient Descent in Continuous Time: A Central Limit Theorem” (with K. Spiliopoulos).
Stochastic Systems, 10 (2), 2020.
21. “Inference for Large Financial Systems” (with G. Schwenkler and K. Giesecke).
Mathematical Finance, 30 (1), 3-46, 2020.
22. “DPM: A deep learning PDE augmentation method with application to large-eddy simulation” (with J. Freund and J. MacArt).
Journal of Computational Physics, 423, 2020.
23. “Universal Price Formation in Financial Markets: Insights from Deep Learning” (with Rama Cont).
Quantitative Finance, 19 (9), 2019.
24. “Large-scale Loan Portfolio Selection” (with K. Giesecke and G. Tsoukalas).
Operations Research, 64 (6), 1239-1255, 2019.

25. “Deep Learning for Limit Order Books.” *Quantitative Finance*, 19 (4), 2019.
26. “DGM: A Deep Learning Algorithm for solving Partial Differential Equations” (with K. Spiliopoulos). *Journal of Computational Physics*, 375, 1339–1364, 2018.
27. “Risk Analysis for Large Pools of Loans” (with K. Giesecke). Winner of the inaugural SIAM Financial Mathematics & Engineering Conference Paper Prize. *Management Science*, 65 (1), 107-121, 2018.
28. “Stochastic Gradient Descent in Continuous Time” (with K. Spiliopoulos). *SIAM Journal on Financial Mathematics*, 8(1), 933-961, 2017.
29. “Large Portfolio Asymptotics for Loss from Default” (with K. Giesecke, K. Spiliopoulos, and R. Sowers). *Mathematical Finance*, 25 (1), 77-114, 2015.
30. “Fluctuation Analysis for the Loss from Default” (with K. Spiliopoulos and K. Giesecke). *Stochastic Processes and their Applications*, 124 (7), 2322-2362, 2014.
31. “A Forward-Backward Algorithm for Stochastic Control Problems” (with S. Ludwig, R. Huang, and G. Papanicolaou). *Proceedings of the First International Conference on Operations Research and Enterprise Systems*, February 2012.
32. “Optimization of Secondary-Air Addition in a Continuous One-Dimensional Spray Combustor” (with L. Rodriquez, A. Siders, and W. Sirignano). *Journal of Propulsion and Power*, 26 (2), 288-294, 2010.

Grants

- U.S. Office of Naval Research grant (approx. \$984,000 total, \$382,000 for Oxford). I am the PI for the Oxford part of this multi-university grant.
- NSF-EPSC grant (£354,523 for Oxford). I am the PI for the UK part of this grant.
- NSF DMS-EPSC grant (£389,812 for Oxford). I am the PI for the UK part of this grant.
- Co-PI on \$16.5 million DoE/NNSA PSAAP III Center (2020-2021). I left my role in the Center due to joining the Univ. of Oxford.

Submitted Proposals Under Review

- EPSC-NSF multi-university proposal (PI: Justin Sirignano, approx. £421,000 for Oxford Math and £271,000 for Oxford Engineering)
- Philip Leverhulme Prize (PI: Justin Sirignano, £100,000)
- EPSC proposal (PI: Sarah Waters, Co-investigators: Justin Sirignano and Alfonso Castrejon-Pita, Oxford Math and Engineering combined budget of approx. £628,000)
- EPSC AI Hub proposal (PI: Michael Bronstein, large proposal involving many investigators)

Computational Allocations

- 120,000 GPU hours on the Summit national supercomputer (2020-2021)
- 3 million GPU hours from the DoE’s Innovative and Novel Computational Impact on Theory and Experiment (INCITE) program (2023, PI: J. MacArt, Co-PI: J. Sirignano)
- 44 million core hours on the Blue Waters national supercomputer (2016-2021).

Professional Activities

1. Invited to be on the Editorial Board of a new journal “Machine Learning for Modeling and Simulation in Engineering & the Sciences”.
2. Associate Editor, *Mathematical Finance*.
3. Managing Editor, *Quantitative Finance*.
4. Associate Editor, *Journal of Dynamics and Games* (an AIMS journal).
5. Associate Editor, Special Issue of *Management Science* on Data-Driven Prescriptive Analytics.
6. Faculty member of the Center for Doctoral Training (CDT) in Mathematics of Random Systems at the University of Oxford.
7. Course director of the MSc programme in Mathematical & Computational Finance at the University of Oxford.
8. Invited participant of the 2021 research programme “Mathematics of Deep Learning” at the Isaac Newton Institute for Mathematical Sciences” at the University of Cambridge.
9. Organized Minisymposiums and Sessions
 - (i) Minisymposium organizer at SIAM Annual Meeting, 2021.
 - (ii) Invited minisymposium organizer at SIAM Annual Meeting, Toronto, 2020.
 - (iii) *Machine learning* minisymposium at SIAM Financial Math Meeting, Toronto, June 2018. 12 speakers.
 - (iv) *Machine learning in finance* session at INFORMS Annual Meeting, Houston, October 2017.
 - (v) *Financial engineering* session at INFORMS Applied Probability Meeting, Northwestern University, July 2017.
 - (vi) *Machine learning for finance* minisymposium at SIAM Financial Mathematics Conference, Austin, November 2016.
 - (vii) *Machine learning for finance* session at INFORMS Annual Meeting, Nashville, November 2016.
 - (viii) *Large-scale portfolio risk* session at INFORMS Annual Meeting, Philadelphia, November 2015.
10. Referee for *SIAM Journal on Applied Mathematics*, *SIAM Journal on Data Science*, *SIAM Journal on Financial Mathematics*, *NeurIPS*, *Constructive Approximation* (Special Issue on Deep Learning), *Stochastic Systems*, *Journal of Machine Learning Research*, *Journal of Computational Physics*, *Quantitative Finance*, *Operations Research*, *Management Science*, *Nature Communications*, and other journals.

Awards and Honors

1. Winner of the inaugural SIAM Financial Mathematics & Engineering Conference Paper Prize.
2. Award for being Ranked Excellent in Teaching for a graduate course on deep learning with two hundred enrolled students.
3. Distinguished Speaker at the NSF Workshop on *Machine Learning in Transport Phenomena* in Dallas, Texas, 2020.
4. Chapman Fellowship at Imperial College London
5. Rose Hills Foundation Engineering Fellowship at Stanford University.
6. Lore von Jaskowsky Memorial Prize, School of Engineering and Applied Sciences at Princeton University, for senior thesis research.

Teaching

1. Currently writing a book on the “Mathematical Foundations of Deep Learning” with K. Spiliopoulos and R. Sowers.
2. “Deep Learning” (2021, 2022, 2023, 2024) at the University of Oxford.
3. “Numerical Methods” in computational finance (Fall 2020) at the University of Oxford.
4. “Deep Learning” (Fall 2016, 2017, 2018, 2019). Graduate course, cross-listed between Industrial Engineering and Computer Science. 200 graduate students (PhD and Masters) enrolled in Fall 2019 from Computer Science, Electrical Engineering, Industrial Engineering, Mechanical Engineering, and Mathematics.
5. “Deep Learning” (Spring 2018, 2019). Undergraduate course.
6. “Deep Learning II” (Spring 2018). Graduate course.
7. “Analysis of Data” (Spring 2017, Spring 2018). Undergraduate course.
8. “Machine Learning” (Spring 2016, Imperial College London, Dept. of Mathematics). Graduate course.

Students and Postdoctoral Researchers

- Currently, my research group has five DPhil students and one postdoctoral researcher.
- A second postdoctoral researcher – funded by the new DMS-EPSRC grant – will join my research group in 2024.

1. Tom Hickling (Math, Oxford, 2023-2026). Postdoctoral researcher funded by an EPSRC grant.
2. Den Waidmann (Math, Oxford, 2022-2026). Dphil studentship fully funded by an Office of Naval Research grant.
3. Nicholas Daultry Ball (Math, Oxford, 2022-2026). Dphil student.
4. Samuel Lam (Math, Oxford, 2022-2026). Dphil student.
5. Ziheng Wang (Math, Oxford, 2024). Dphil Thesis on machine learning methods for optimizing SDE models.
6. Deqing Jiang (Math, Oxford, 2024). Dphil Thesis on machine learning methods for solving high-dimensional PDEs. (Co-advised with Professor Sam Cohen.)
7. Lei Fan (ISE, UIUC, 2016-2021). PhD Thesis: “Machine Learning Methods for Pricing and Hedging Financial Derivatives”.
8. Yunxiang Zhang (Applied Math/CS/Stats, UIUC, 2018). Senior Thesis: “Multiscale Long Short-Term Memory for Limit Order Book.” (Now a PhD student at Cornell Operations Research & Information Engineering.)

Selected Presentations

1. Invited Presentation at Scientific Machine Learning: Analysis and Algorithms Workshop, Dept. of Mathematics at University of Maryland, February 2024.
2. Seminar at Imperial College London, Dept. of Mathematics, Fall 2022.
3. Seminar at the Oxford Thermofluids Institute, Fall 2022.
4. Oxford-Princeton Workshop on Stochastic Analysis and Mathematical Finance, Fall 2022.
5. Two Sigma Investments, April 2022. Invited Speaker.
6. Google Deepmind, January 2022. Invited Seminar.
7. London Business School, December 2021. Invited Seminar.
8. Brown University, Dept. of Applied Mathematics, November 2021. Invited Seminar.
9. Workshop on Deep Learning and Partial Differential Equations, Isaac Newton Institute at the University of Cambridge, November 2021. Invited Presentation.
10. Workshop on Mean-field Reinforcement Learning hosted by King's College London and Université de Paris, 2021. Invited Presentation.
11. Workshop on Deep Learning and Partial Differential Equations, Isaac Newton Institute at the University of Cambridge, November 2021. Invited Presentation.
12. Symposium on Model Consistent Data Driven Turbulence Modeling, June 2021. Invited Speaker.
13. SIAM Annual Meeting, 2021. Minisymposium organizer and presenter.
14. SIAM Conference on Financial Mathematics & Engineering, June 2021. Invited Presentation.
15. SIAM Conference on Applications of Dynamical Systems, June 2021. Invited Presentation.
16. Mathematical & Computational Finance seminar, University of Oxford, May 2021.
17. World Finance Seminar, May 2021. Invited Presentation.
18. UCLA, Dept. of Mathematics, February 2021. Invited Seminar.
19. Seminar in Physics & Machine Learning, University of Oxford, November 2020.
20. Maven Securities, October 2020. Invited Presentation.
21. NSF Workshop on *Machine Learning in Transport Phenomena* in Dallas, Texas, February 2020. Distinguished Speaker.
22. Two Sigma Investments, New York City, January 2020. Invited Seminar.
23. Seminar at the University of Oxford, Dept. of Mathematics, October 2019. *Mathematical Finance* seminar.
24. Seminar at the University of Oxford, Dept. of Mathematics, October 2019. *Data Science* seminar.
25. University of Michigan, Dept. of Mathematics, October 2019. Invited Seminar.
26. Colloquium at UCLA, Dept. of Mathematics, May 2019.
27. Workshop on Machine Learning at the University of Toronto, Fields Institute, September 2019. Invited Speaker.
28. Carnegie Mellon University, Dept. of Statistics, January 2019. Invited Seminar.

29. Columbia University, Dept. of Industrial Engineering & Operations Research, February 2019. Invited Seminar.
30. SIAM Financial Mathematics conference, June 2019.
31. SIAM Annual Meeting, July 2018.
32. London Quantitative Finance Seminar, May 2018.
33. Deep Learning Workshop, National Center for Supercomputing Applications, UIUC, October 2017.
34. Princeton University, Dept. of Operations Research and Financial Engineering, 2017. Invited Seminar.
35. INFORMS Applied Probability Society Conference, Northwestern University, July 2017. Invited Presentation.
36. Northwestern University, April 2017. Invited Seminar.
37. J.P. Morgan, New York City, August 2017. Invited Seminar.
38. UIUC Business School, February 2017. Invited Seminar.
39. SIAM Financial Mathematics Conference, Austin, Texas, November 2016. Co-organized minisymposium on machine learning in finance.
40. Bank of England, London, May 2016. Invited Seminar.
41. INFORMS Annual Meeting, Nashville, November 2016. Invited Presentation.
42. London Business School, London, June 2016. Invited Seminar.
43. Seminar at Oxford University, May 2016.
44. London-Paris Bachelier Workshop on Mathematical Finance, London, September 2015. Invited Speaker.
45. Lending Club, San Francisco, June 2015.
46. IPAM Workshop on Systemic Risk and Financial Networks, Los Angeles, 2015.
47. SIAM Financial Mathematics and Engineering Meeting, Chicago, 2014. Invited Speaker.
48. INFORMS Annual Meeting, San Francisco, 2014. Invited Speaker.
49. Joint Mathematics Meeting, Baltimore, 2014. Invited Speaker.
50. INFORMS Annual Meeting, Phoenix, October, 2012. Invited Speaker.
51. SIAM Financial Mathematics and Engineering Meeting, Minneapolis, 2012. Chair of the *Credit Risk* session.
52. Annual Meeting of the Canadian Applied and Industrial Mathematics Society, Toronto, 2012. Invited Speaker.
53. 5th Financial Risks International Forum, Paris, France, 2012.