

## Justin Sirignano

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### Academic Positions

*Professor of Mathematics*, University of Oxford  
Mathematical Institute August 2024-

*Associate Professor*, University of Oxford  
Mathematical Institute July 2020-August 2024

*Assistant Professor*, University of Illinois at Urbana-Champaign  
(Unpaid Leave of Absence 2020-2022) 2016 - 2022  
College of Engineering  
Department of Industrial & Enterprise Systems Engineering  
Coordinated Science Lab (Signals, Inference, and Networks group)

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

### Education

*Stanford University, PhD* 2010-2015  
Management Science & Engineering

*Princeton University, B.S.E.* 2006-2010  
Major: Operations Research & Financial Engineering  
Graduated *summa cum laude*  
Elected to Phi Beta Kappa, Tau Beta Pi, and Sigma Xi

### Research Groups

The Mathematical Institute (Oxford's Department of Mathematics) consists of research groups covering a range of areas in pure and applied mathematics. I am a faculty member in the following research groups:

- Mathematical & Computational Finance
- Machine Learning & Data Science
- Oxford Centre for Industrial & Applied Mathematics (OCIAM)

### Research Interests

- Applied Mathematics, Stochastic Analysis, and Optimization
- Mathematical finance
- Mathematical analysis of deep learning models
- Scientific machine learning (especially machine learning for PDE models)

## Journal Publications

1. “Convergence Analysis of Real-time Recurrent Learning (RTRL) for a class of Recurrent Neural Networks.” S. Lam, J. Sirignano, and K. Spiliopoulos. arXiv:2501.08040, 2025.
2. “Online Optimisation of Machine Learning Collision Models to Accelerate Direct Molecular Simulation of Rarefied Gas Flows.” N. Ball, J. MacArt, and J. Sirignano. arXiv:2411.13423, 2024.
3. “Continuous-time stochastic gradient descent for optimizing over the stationary distribution of stochastic differential equations.” Z. Wang and J. Sirignano. arXiv: 2202.06637. *Mathematical Finance*, 34 (2), 348-424, 2024.
4. “Machine Learning Methods for Pricing Financial Derivatives.” L. Fan and J. Sirignano, arXiv:2406.00459, 2024.
5. “Weak Convergence Analysis of Online Neural Actor-Critic Algorithms.” S. Lam, J. Sirignano, and Z. Wang, arXiv:2403.16825, 2024.  
Invited Revision at *Mathematics of Operations Research*.
6. \* “Kernel Limit of Recurrent Neural Networks Trained on Ergodic Data Sequences”. S. Lam, J. Sirignano, and K. Spiliopoulos. arXiv:2308.14555, 2023.  
Minor Revision at *Annals of Applied Probability*.  
Contribution: This is the first paper to rigorously prove asymptotics for recurrent neural networks (RNNs) trained with the truncated backpropagation through time algorithm; the limit analysis of RNNs required the development of new mathematical techniques for analyzing mean-field limits of neural networks.
7. “Global Convergence of Deep Galerkin and PINNs Methods for Solving Partial Differential Equations”. D. Jiang, J. Sirignano, and S. Cohen. arXiv:2305.06000, 2023.
8. \* “Neural Q-learning for solving Elliptic PDEs.” S. Cohen, D. Jiang, and J. Sirignano. *Journal of Machine Learning Research*, 2023.  
Contribution: Neural network algorithms are being widely-used in practice for numerically solving PDEs. This is the first paper to rigorously prove convergence of a neural network algorithm trained with gradient descent to the solution of the PDE.
9. “PDE-constrained Models with Neural Network Terms: Optimization and Global Convergence.” J. Sirignano, J. MacArt, and K. Spiliopoulos. arXiv:2105.08633. *Journal of Computational Physics*, 2023.
11. \* “Deep Learning Closure Models for Large-Eddy Simulation of Flows around Bluff Bodies.” J. Sirignano and J. MacArt. *Journal of Fluid Mechanics*, 2023.  
Contribution: This paper developed an accurate deep learning closure model for large-eddy simulation which outperformed existing closure models in the literature.
12. “Dynamic Deep Learning LES Closures: Online Optimization With Embedded DNS.” J. Sirignano and J. MacArt. arXiv: 2303.02338, 2023.
13. “Deep Learning Closure of the Navier–Stokes Equations for Transition-Continuum Flows.” A. Nair, J. Sirignano, M. Panesi, and J. MacArt. *AIAA Journal*, Vol. 61, No. 12 (2023), pp. 5484-5497, 2023.
14. “Online Adjoint Methods for Optimization of Partial Differential Equations.” J. Sirignano and K. Spiliopoulos. *Applied Mathematics and Optimization*, 85 (2), 2022.

15. “A Forward Propagation Algorithm for Online Optimization of Nonlinear Stochastic Differential Equations.” Z. Wang and J. Sirignano. arXiv:2207.04496, 2022.
16. “Global Convergence of the ODE Limit for Online Actor-Critic Algorithms in Reinforcement Learning.” Z. Wang and J. Sirignano. arXiv:2108.08655, 2021  
Invited Revision at *Stochastic Systems*.
17. “Asymptotics of Reinforcement Learning with Neural Networks.” J. Sirignano and K. Spiliopoulos.  
*Stochastic Systems*, 2021.
18. “Deep Learning for Mortgage Risk.” A. Sadhwani, K. Giesecke, and J. Sirignano.  
*Journal of Financial Econometrics*, 19 (2), 2021.
19. \* “Mean Field Analysis of Deep Neural Networks.” J. Sirignano and K. Spiliopoulos.  
*Mathematics of Operations Research*, 2021.  
Contribution: This paper rigorously proved a mean-field limit for a multi-layer neural network with two hidden layers. The analysis required addressing a non-trivial closure problem in the mean-field limit analysis.
20. “Embedded training of neural-network sub-grid-scale turbulence models.” J. MacArt, J. Sirignano, and J. Freund.  
*Physical Review of Fluids*, 6 (5), 2021.
21. “Mean Field Analysis of Neural Networks: A Law of Large Numbers.” J. Sirignano and K. Spiliopoulos.  
*SIAM Journal on Applied Mathematics*, 80 (2), 725-752, 2020.
22. “Mean Field Analysis of Neural Networks: A Central Limit Theorem.” J. Sirignano and K. Spiliopoulos.  
*Stochastic Processes and their Applications*, 130 (3), 1820-1852, 2020.
23. “Stochastic Gradient Descent in Continuous Time: A Central Limit Theorem.” J. Sirignano and K. Spiliopoulos.  
*Stochastic Systems*, 10 (2), 2020.
24. “Inference for Large Financial Systems.” K. Giesecke, G. Schwenkler, and J. Sirignano.  
*Mathematical Finance*, 30 (1), 3-46, 2020.
25. “DPM: A deep learning PDE augmentation method with application to large-eddy simulation.” J. Sirignano, J. MacArt, and J. Freund.  
*Journal of Computational Physics*, 423, 2020.
26. “Universal Price Formation in Financial Markets: Insights from Deep Learning.” J. Sirignano and R. Cont.  
*Quantitative Finance*, 19 (9), 2019.
27. “Large-scale Loan Portfolio Selection.” J. Sirignano, G. Tsoukalas, and K. Giesecke.  
*Operations Research*, 64 (6), 1239-1255, 2019.
28. “Deep Learning for Limit Order Books.” J. Sirignano.  
*Quantitative Finance*, 19 (4), 2019.
29. \* “DGM: A Deep Learning Algorithm for solving Partial Differential Equations.” J. Sirignano and K. Spiliopoulos.  
*Journal of Computational Physics*, 375, 1339–1364, 2018.

Contribution: High-dimensional PDEs are computationally challenging to solve using traditional numerical methods. This paper developed deep learning algorithm for solving high-dimensional PDEs; the methods/ideas in the paper have become the basis for a large amount of subsequent research in the field.

30. “Risk Analysis for Large Pools of Loans.” J. Sirignano and K. Giesecke. Winner of the inaugural SIAM Financial Mathematics & Engineering Conference Paper Prize. *Management Science*, 65 (1), 107-121, 2018.
31. \* “Stochastic Gradient Descent in Continuous Time.” J. Sirignano and K. Spiliopoulos. *SIAM Journal on Financial Mathematics*, 8(1), 933-961, 2017.  
Contribution: This paper rigorously proved convergence for continuous-time stochastic gradient descent algorithms; the mathematical techniques developed in the paper have been the foundation for research on continuous-time statistical learning in a number of subsequent publications.
32. “Large Portfolio Asymptotics for Loss from Default.” K. Giesecke, K. Spiliopoulos, R. Sowers, and J. Sirignano. *Mathematical Finance*, 25 (1), 77-114, 2015.
33. “Fluctuation Analysis for the Loss from Default.” K. Spiliopoulos, J. Sirignano, and K. Giesecke. *Stochastic Processes and their Applications*, 124 (7), 2322-2362, 2014.
34. “Optimization of Secondary-Air Addition in a Continuous One-Dimensional Spray Combustor.” J. Sirignano, L. Rodriguez, A. Siders, and W. Sirignano. *Journal of Propulsion and Power*, 26 (2), 288-294, 2010.

## **Publications in Conference Proceedings**

35. “Physics-constrained deep learning-based model for non-equilibrium flows” (with E. Monti, N. Singh, J. MacArt, M. Panesi, and G. Gori). Proceedings of AIAA SciTech Forum, 2024.
36. “Adjoint-Trained Deep-Learning Closures of the Navier–Stokes Equations for 2D Nonequilibrium Flows” (with A. Nair, D. Waidmann, N. Singh, M. Panesi, and J. MacArt). Proceedings of AIAA SciTech Forum, 2024.
37. “Adjoint Optimization of the BGK Equation with an Embedded Neural Network for Reduced-Order Modeling of Hypersonic Flows” (with N. Daultry Ball, M. Panesi, and J. MacArt). Proceedings of AIAA SciTech Forum, 2024.
38. “Large Eddy Simulation of Airfoil Flows Using Adjoint-Trained Deep Learning Closure Models” (with T. Hickling and J. MacArt). Proceedings of AIAA SciTech Forum, 2024.
39. “Entropy-stable Deep Learning for Navier–Stokes Predictions of Transitional-regime Flows” (with A. Nair, M. Panesi, and J. MacArt). Proceedings of AIAA SciTech Forum, 2023.
40. “Deep Learning Closure of the Navier–Stokes Equations for Transitional Flows” (with J. MacArt and M. Panesi). Proceedings of AIAA SciTech Forum, 2022.
41. “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.

## 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. Funds a four year DPhil student at Oxford. Dates: June 1, 2022 - May 31, 2026.
- NSF-EPSRC grant (£354,523 for Oxford). I am the PI for the UK part of this grant. Funds a three-year postdoctoral researcher at Oxford. Dates: March 1, 2023 - February 28, 2026.
- NSF DMS-EPSRC grant (£389,812 for Oxford). I am the PI for the UK part of this grant. Funds a three-year postdoctoral researcher at Oxford. Awarded on August 14, 2023. Anticipated dates of grant duration once postdoctoral researcher is appointed: August 1, 2024 - July 31, 2026.
- EPSRC AI Hub on the Mathematical and Computational Foundations of AI (PI: Michael Bronstein, large grant involving multiple universities and many investigators).
- Co-PI (2020-2021) on \$16.5 million DoE/NSA PSAAP III Center. I left my role in the Center due to joining the Univ. of Oxford.
- Host PI for Schmidt AI in Science Fellowship (2024-2026). Funds a two year postdoctoral research fellowship.
- Funding for two (four year) DPhil student positions from the UK government (approx. £522,000, co-supervised with Sam Cohen, 2024-2028).

## Computational Allocations

- 8 million GPU hours on Frontier from the DoE's Innovative and Novel Computational Impact on Theory and Experiment (INCITE) program (2025, PI: J. MacArt, Co-PIs: J. Sirignano, T. Hickling, D. Dehtyriov)
- 160,000 GPU hours on the EPSRC HPC facility Baskerville (2024; PI: J. Sirignano, Co-PIs: J. MacArt, T. Hickling)
- 1.5 million GPU hours from the U.S. Department of Energy (DoE) SummitPLUS program (2024, PI: J. MacArt, Co-PIs: J. Sirignano, T. Hickling)
- EPSRC HPC allocation: 160,000 GPU hours on the Baskerville HPC system (January 4, 2024 - December 31, 2024, PI: J. Sirignano, Co-PIs: J. MacArt, T. Hickling)
- 3 million GPU hours from the DoE's INCITE program (2023, PI: J. MacArt, Co-PI: J. Sirignano)
- 120,000 GPU hours on the Summit national supercomputer (2020-2021)
- 44 million core hours on the Blue Waters national supercomputer (2016-2021).

## Teaching

1. Recently wrote a book “Mathematical Foundations of Deep Learning” with K. Spiliopoulos and R. Sowers, which has been accepted to be published by the American Mathematical Society.
2. “Deep Learning” (2021, 2022, 2023, 2024, 2025) at the University of Oxford.
3. Supervision of 3 – 4 MSc dissertations per year at the University of Oxford.

4. “Numerical Methods” in computational finance (2020) at the University of Oxford.
5. University of Illinois: “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.
6. University of Illinois: “Deep Learning” (Spring 2018, 2019). Undergraduate course.
7. University of Illinois: “Deep Learning II” (Spring 2018). Graduate course.
8. University of Illinois: “Analysis of Data” (Spring 2017, Spring 2018). Undergraduate course.
9. “Machine Learning” (Spring 2016, Imperial College London, Dept. of Mathematics). Graduate course.

### University Administration and Academic Leadership

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.
  - Implemented changes leading to an approx. 200% increase in the number of applications.
  - MSc programme has expanded from  $\sim 35$  students to 55 students.
  - Co-organized an internship programme for students with banks, investment companies, and hedge funds. The quantitative research conducted during the internship is part of the students’ MSc dissertations.
  - Organized the “Careers in Quantitative Finance” seminar series where companies present internship and job opportunities to the students. Participants have included J.P. Morgan, Nomura, Deutsche Bank, Citibank, EDF Trading, Mazars, NatWest Markets (formerly Royal Bank of Scotland), QRT, Cubist Systematic, and Lloyds Bank.
  - Developed and taught a new course on deep learning.
  - Obtained GPU computing resources for the MSc programme and introduced high-performance computing.
  - Re-designed Python course to focus on modern data science.
  - Introducing a new course on cryptocurrency and blockchain.
  - Organized a new Advisory Board to establish better connections with industry.

- Obtained a small endowment (£2,500) from MUFG Securities to fund an MSc Best Thesis Prize.
  - Successfully nominated students for the Natixis Prize for the Best Thesis for mathematical finance MSc programmes in Europe (Oxford received the prize in both 2021 and 2022).
  - Collaborated with faculty and academic staff to obtain scholarship funds (£100,000) for the MSc programme.
  - Collaborated with faculty and academic staff to develop a new Industry Engagement Officer position for the department.
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.

## Students and Postdoctoral Researchers

- Currently, my research group has six DPhil students and three postdoctoral researchers.
- 1. Tom Hickling (Math, Oxford, 2023-2026). Postdoctoral researcher funded by an EPSRC grant.
- 2. Daniel Dehtyriov (Math, Oxford, 2024-2026). Postdoctoral researcher funded by Schmidt AI Fellowship.
- 3. Den Waidmann (Math, Oxford, 2022-2026). DPhil studentship fully funded by an Office of Naval Research grant.
- 4. Nicholas Daultry Ball (Math, Oxford, 2022-2026). DPhil student.
- 5. Samuel Lam (Math, Oxford, 2022-2026). DPhil student.
- 6. Jackson Hebner (Math, Oxford, 2024-2028). DPhil student. (Co-advised with Prof. Sam Cohen.)
- 7. Finnley Connellan (Math, Oxford, 2024-2028). DPhil student. (Co-advised with Prof. Sam Cohen.)
- 8. Jason Li (Math, Oxford, 2024-2028). DPhil student. (Co-advised with Prof. Sarah Waters.)
- 9. Ziheng Wang (Math, Oxford, 2024). DPhil Thesis on machine learning methods for optimizing SDE models.
- 10. Deqing Jiang (Math, Oxford, 2024). DPhil Thesis on machine learning methods for solving high-dimensional PDEs. (Co-advised with Prof. Sam Cohen.)
- 11. Lei Fan (ISE, UIUC, 2016-2021). PhD Thesis: “Machine Learning Methods for Pricing and Hedging Financial Derivatives”.
- 12. 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. SIAM Financial Mathematics, Miami, July 2025, Invited Minisymposium Speaker.
2. University of Waterloo, Dept. of Applied Mathematics, 2025. Invited Seminar.
3. PSU-Purdue-UMD Joint Seminar on Mathematical Data Science, 2025.
4. UCLA, Dept. of Mathematics, January 2024. Invited Seminar.
5. Invited Presentation at the 4th ACM International Conference on AI in Finance, November 2023.
6. Seminar at Imperial College London, Dept. of Mathematics, Fall 2022.
7. Seminar at the Oxford Thermofluids Institute, Fall 2022.
8. Oxford-Princeton Workshop on Stochastic Analysis and Mathematical Finance, Fall 2022.
9. Two Sigma Investments, April 2022. Invited Speaker.



10. Google Deepmind, January 2022. Invited Seminar.
11. London Business School, December 2021. Invited Seminar.
12. Brown University, Dept. of Applied Mathematics, November 2021. Invited Seminar.
13. Workshop on Deep Learning and Partial Differential Equations, Isaac Newton Institute at the University of Cambridge, November 2021. Invited Presentation.
14. Workshop on Mean-field Reinforcement Learning hosted by King's College London and Université de Paris, 2021. Invited Presentation.
15. Workshop on Deep Learning and Partial Differential Equations, Isaac Newton Institute at the University of Cambridge, November 2021. Invited Presentation.
16. Symposium on Model Consistent Data Driven Turbulence Modeling, June 2021. Invited Speaker.
17. SIAM Annual Meeting, 2021. Minisymposium organizer and presenter.
18. SIAM Conference on Financial Mathematics & Engineering, June 2021. Invited Presentation.
19. SIAM Conference on Applications of Dynamical Systems, June 2021. Invited Presentation.
20. UCLA, Dept. of Mathematics, February 2021. Invited Seminar.
21. Maven Securities, October 2020. Invited Presentation.
22. NSF Workshop on *Machine Learning in Transport Phenomena* in Dallas, Texas, February 2020. Distinguished Speaker.
23. Two Sigma Investments, New York City, January 2020. Invited Seminar.
24. University of Michigan, Dept. of Mathematics, October 2019. Invited Seminar.
25. Colloquium at UCLA, Dept. of Mathematics, May 2019.
26. Workshop on Machine Learning at the University of Toronto, Fields Institute, September 2019. Invited Speaker.
27. Carnegie Mellon University, Dept. of Statistics, January 2019. Invited Seminar.
28. Columbia University, Dept. of Industrial Engineering & Operations Research, February 2019. Invited Seminar.
29. SIAM Financial Mathematics conference, June 2019.
30. SIAM Annual Meeting, July 2018.
31. London Quantitative Finance Seminar, May 2018.
32. Princeton University, Dept. of Operations Research and Financial Engineering, 2017. Invited Seminar.
33. INFORMS Applied Probability Society Conference, Northwestern University, July 2017. Invited Presentation.
34. Northwestern University, April 2017. Invited Seminar.

35. J.P. Morgan, New York City, August 2017. Invited Seminar.
36. SIAM Financial Mathematics Conference, Austin, Texas, November 2016. Co-organized minisymposium on machine learning in finance.
37. Bank of England, London, May 2016. Invited Seminar.
38. INFORMS Annual Meeting, Nashville, November 2016. Invited Presentation.
39. London Business School, London, June 2016. Invited Seminar.
40. London-Paris Bachelier Workshop on Mathematical Finance, London, September 2015. Invited Speaker.
41. SIAM Financial Mathematics and Engineering Meeting, Chicago, 2014. Invited Speaker.
42. INFORMS Annual Meeting, San Francisco, 2014. Invited Speaker.
43. Joint Mathematics Meeting, Baltimore, 2014. Invited Speaker.
44. INFORMS Annual Meeting, Phoenix, October, 2012. Invited Speaker.
45. SIAM Financial Mathematics and Engineering Meeting, Minneapolis, 2012. Chair of the *Credit Risk* session.
46. Annual Meeting of the Canadian Applied and Industrial Mathematics Society, Toronto, 2012. Invited Speaker.
47. 5th Financial Risks International Forum, Paris, France, 2012.