Ludovico T. Giorgini

C.L.E. Moore Instructor in Mathematics | Massachusetts Institute of Technology
ludogio@mit.edu | +1 (617) 229-8757 | MIT Profile | GitHub | ORCID

About Me

I am an applied mathematician working at the intersection of applied probability, statistical physics, and scientific machine learning. My research develops mathematical and computational methods for extracting effective low-dimensional descriptions from complex, high-dimensional systems. I am particularly interested in multiscale problems in fluid dynamics, geophysics, and nonequilibrium systems.

Academic Appointments

Massachusetts Institute of Technology — Cambridge, MA, USA
C.L.E. Moore Instructor in Mathematics — Sep 2024–present

Nordita — Stockholm, Sweden
Postdoctoral Researcher — Jun 2024–Sep 2024

Education

Stockholm University and Nordita — Stockholm, Sweden
Ph.D. in Theoretical Physics — Mar 2019–May 2024
- Dissertation: *A Serendipitous Journey through Stochastic Processes*
- Advisor: Prof. John S. Wettlaufer (Yale University and Nordita)

Sapienza University of Rome — Rome, Italy
M.Sc. in Theoretical Physics, 110/110 cum laude — Oct 2016–Oct 2018
- Thesis: *High-Order Behavior of the Correlation Functions of a ϕ^4 Theory*
- Advisor: Prof. Giorgio Parisi (Sapienza University of Rome)

Sapienza University of Rome — Rome, Italy
B.Sc. in Physics, 110/110 — Oct 2013–Oct 2016
- Thesis: *The Birth of the Universe: From Friedmann's Equations to the Inflationary Model*
- Advisor: Prof. Alessandro Melchiorri (Sapienza University of Rome)

Research

Appointments and Experience

Aeolus Labs — San Francisco, CA, USA
Research Consultant — Jul 2025–Aug 2025

Massachusetts Institute of Technology — Cambridge, MA, USA
Research Intern — Jul 2023

Woods Hole Oceanographic Institution — Woods Hole, MA, USA
Geophysical Fluid Dynamics Fellow — Jun–Aug 2022

Atomki; CEA Saclay; Missouri University of Science and Technology — Debrecen; Saclay; Rolla
Research Intern — Nov 2018–Feb 2019; Sep 2022; Jul 2023; Aug 2024

Funding and Proposals

- *Collaborative Research: Predicting Arctic Sea-Ice Thickness Through Data-Enabled Stochastic Modeling*. Co-PI with Prof. John S. Wettlaufer (Yale University); NSF Arctic Research Opportunities, NSF 23-572; collaborative full proposal; $613,646 requested; submitted July 2026.
- *Stochastic Prediction of Spatial Snow-Depth and Snow-Cover Evolution from Multiscale Observations*. Co-PI with Prof. John S. Wettlaufer (Yale University); U.S. Army Engineer Research and Development Center, Cold Regions Research and Engineering Laboratory, CRREL-2; two-year pre-proposal; proposed price of $436,000 per year; submitted July 2026.

- *Risk-Aware Situational Awareness for Navigation through Marginal Ice*. Co-PI with Prof. John S. Wettlaufer (Yale University); U.S. Army Engineer Research and Development Center, Cold Regions Research and Engineering Laboratory, CRREL-5; two-year pre-proposal; proposed price of $434,000 per year; submitted July 2026.

Software

- **DiscreteTransformers.jl**. Transformer-based ensemble forecasting and scenario generation for discretized time series.
- **ContinuousTransformers.jl**. Continuous-state, delay-embedded transformer models for probabilistic forecasting.
- **FastSDE.jl**. High-performance Julia simulation of deterministic and stochastic dynamical systems.
- **ScoreEstimation.jl**. KGMM-based score estimation using clustered Gaussian mixtures and neural interpolation.
- **ParameterCalibration.jl**. GFDT-based sensitivity estimation and statistical parameter calibration from a single baseline simulation.
- **ScoreUNet1D.jl**. Denoising-score-matching U-Net models and Langevin validation for one-dimensional fields.
- **StateDependentMobility.jl**. Learning and validation of state-dependent mobility tensors from finite-lag trajectories and conditional scores.

Invited Talks and Seminars

- **2026**. Department of Mathematics, University of Rochester, Rochester, NY. "Learning Dynamics from Statistics: A Score-Based Approach for Modeling Complex Systems" (Feb 9).
- **2025**. Statistical Mechanics of the Climate System and of Ecosystems, Leicester, UK. "Response Theory via Score Modeling" (invited lecture, Jul 1–3).
- **2025**. University of Rome Tor Vergata, Rome, Italy. "Response Theory via Score Modeling" (invited seminar, Jun 24).
- **2024**. MIT Physical Mathematics Seminar, Cambridge, MA. "Response Theory via Generative Score Modeling" (Sep 24).

Selected Conference Presentations

- **2026**. SIAM Conference on Uncertainty Quantification, Minneapolis, MN. "Response Theory via Score Modeling" (contributed talk, Mar 22).
- **2025**. APS Division of Fluid Dynamics, Houston, TX. "From Memory-Driven Chaos to Markovian Dynamics in One-Dimensional Pilot-Wave Hydrodynamics" (contributed talk, Nov 24).
- **2024**. SIAM Conference on Uncertainty Quantification, Trieste, Italy. "Tackling the Curse of Dimensionality: A Generative Modeling Approach to Linear Response Theory" (contributed talk, Feb 27–Mar 1).
- **2023**. APS March Meeting, Las Vegas, NV. "Non-Gaussian Stochastic Dynamical Model for the El Niño Southern Oscillation" (contributed focus-session talk, Mar 6).
- **2021**. ICML Time Series Workshop, online. "Modeling the El Niño Southern Oscillation with Neural Differential Equations" (contributed paper and oral presentation, Jul).
- Poster presentations at the AGU Fall Meeting in 2019, 2020, 2021, 2022, 2023, and 2024.

Publications

Peer-Reviewed Journal Articles

1. **L. T. Giorgini**, "Score-Based Modeling of Effective Langevin Dynamics," *Physical Review E* **114**, L012102 (2026).
2. **L. T. Giorgini**, T. Bischoff, and A. N. Souza, "KGMM: A K-means Clustering Approach to Gaussian Mixture Modeling for Score Function Estimation," *Physica D: Nonlinear Phenomena* **495**, 135274 (2026).
3. G. Del Felice and **L. T. Giorgini**, "Integrating Score-Based Generative Modeling and Neural ODEs for Accurate Representation of Multiscale Chaotic Dynamics," *Chaos* **36**, 063143 (2026).
4. **L. T. Giorgini**, F. Falasca, and A. N. Souza, "Predicting Forced Responses of Probability Distributions via the Fluctuation–Dissipation Theorem and Generative Modeling," *Proceedings of the National Academy of Sciences* **122**, e2509578122 (2025).
5. **L. T. Giorgini**, A. N. Souza, D. Lippolis, P. Cvitanović, and P. J. Schmid, "Learning Dissipation and Instability Fields from Chaotic Dynamics," *Physica D: Nonlinear Phenomena* **481**, 134865 (2025).
6. **L. T. Giorgini**, K. Deck, T. Bischoff, and A. N. Souza, "Response Theory via Generative Score Modeling," *Physical Review Letters* **133**, 267302 (2024).
7. **L. T. Giorgini**, A. N. Souza, and P. J. Schmid, "Reduced Markovian Models of Dynamical Systems," *Physica D: Nonlinear Phenomena* **470**, 134393 (2024).
8. **L. T. Giorgini**, W. Moon, and J. S. Wettlaufer, "Analytical Survival Analysis of the Non-autonomous Ornstein–Uhlenbeck Process," *Journal of Statistical Physics* **191**, 138 (2024).
9. U. D. Jentschura and **L. T. Giorgini**, "Enhanced and Generalized One-Step Neville Algorithm: Fractional Powers and Access to the Convergence Rate," *Computer Physics Communications* **303**, 109280 (2024).

10. **L. T. Giorgini**, U. D. Jentschura, E. M. Malatesta, T. Rizzo, and J. Zinn-Justin, "Instantons in ϕ^4 Theories: Transseries, Virial Theorems, and Numerical Aspects," *Physical Review D* **110**, 036003 (2024) (Editors' Suggestion).
11. N. D. B. Keyes, **L. T. Giorgini**, and J. S. Wettlaufer, "Stochastic Paleoclimatology: Modeling the EPICA Ice Core Climate Records," *Chaos* **33**, 093132 (2023).
12. **L. T. Giorgini**, R. Eichhorn, M. Das, W. Moon, and J. S. Wettlaufer, "Thermodynamic Cost of Erasing Information in Finite Time," *Physical Review Research* **5**, 023084 (2023).
13. **L. T. Giorgini**, W. Moon, N. Chen, and J. S. Wettlaufer, "Non-Gaussian Stochastic Dynamical Model for the El Niño Southern Oscillation," *Physical Review Research* **4**, L022065 (2022).
14. **L. T. Giorgini**, U. D. Jentschura, E. M. Malatesta, G. Parisi, T. Rizzo, and J. Zinn-Justin, "Correlation Functions of the Anharmonic Oscillator: Numerical Verification of Two-Loop Corrections to the Large-Order Behavior," *Physical Review D* **105**, 105012 (2022).
15. W. Moon, **L. T. Giorgini**, and J. S. Wettlaufer, "Analytical Solution of Stochastic Resonance in the Nonadiabatic Regime," *Physical Review E* **104**, 044130 (2021).
16. S. H. Lim, **L. T. Giorgini**, W. Moon, and J. S. Wettlaufer, "Predicting Critical Transitions in Multiscale Dynamical Systems Using Reservoir Computing," *Chaos* **30**, 123126 (2020).
17. **L. T. Giorgini**, W. Moon, and J. S. Wettlaufer, "Analytical Survival Analysis of the Ornstein–Uhlenbeck Process," *Journal of Statistical Physics* **181**, 2404–2414 (2020).
18. **L. T. Giorgini**, U. D. Jentschura, E. M. Malatesta, G. Parisi, T. Rizzo, and J. Zinn-Justin, "Two-Loop Corrections to the Large-Order Behavior of Correlation Functions in the One-Dimensional N-Vector Model," *Physical Review D* **101**, 125001 (2020).
19. **L. T. Giorgini**, S. H. Lim, W. Moon, and J. S. Wettlaufer, "Precursors to Rare Events in Stochastic Resonance," *EPL* **129**, 40003 (2020) (Editor's Choice).

Preprints

20. **L. T. Giorgini**, "Conditional Score-Based Modeling of Effective Langevin Dynamics," arXiv:2604.23952 (2026).
21. P. Patra, **L. T. Giorgini**, and J. S. Wettlaufer, "Stochastic Coupling of Climate Variables and Ice Volume over the Late Pleistocene Glacial Cycles," arXiv:2603.26937 (2026).
22. **L. T. Giorgini**, T. Bischoff, and A. N. Souza, "Statistical Parameter Calibration via the Generalized Fluctuation–Dissipation Theorem and Generative Modeling," arXiv:2509.19660 (2025).
23. **L. T. Giorgini**, T. Bischoff, and A. N. Souza, "Reduced-Order Modeling of Cyclo-Stationary Time Series Using Score-Based Generative Methods," arXiv:2508.19448 (2025).

Conference and Workshop Publications

24. **L. T. Giorgini**, S. H. Lim, W. Moon, N. Chen, and J. S. Wettlaufer, "Modeling the El Niño Southern Oscillation with Neural Differential Equations," Time Series Workshop at ICML 2021 (2021).

Teaching and Mentoring

Course Instruction

Massachusetts Institute of Technology — Cambridge, MA, USA
Instructor — Fall 2026
- 18.305, *Advanced Analytic Methods in Science and Engineering* (graduate).

Massachusetts Institute of Technology — Cambridge, MA, USA
Instructor — Spring 2026
- 18.354J, *Nonlinear Dynamics II: Continuum Systems* (graduate).

Massachusetts Institute of Technology — Cambridge, MA, USA
Teaching Assistant and Recitation Instructor — Sep 2024–May 2026
- *Multivariable Calculus* (undergraduate), Fall 2025 and Spring 2026.
- *Differential Equations* (undergraduate), Fall 2024 and Spring 2025.

Stockholm University — Stockholm, Sweden
Teaching Assistant — Jan 2020–Mar 2023
- *Statistical Physics* (graduate), Spring 2023.
- *Mathematical Methods for Physicists* (graduate), Fall 2020, Fall 2021, and Fall 2022.
- *Analytical Mechanics* (graduate), Spring 2022.

Supervision and Mentoring

Massachusetts Institute of Technology Cambridge, MA, USA
Undergraduate Research Opportunities Program Supervisor Summer 2026

- Supervised Tristan Sprole and Laura Lerebours (MIT) on climate detection and attribution using statistical response-operator methods.

Massachusetts Institute of Technology Cambridge, MA, USA
Master's Thesis Supervisor Apr 2025–Oct 2025

- Supervised Giulio Del Felice (ETH Zurich) on score-based generative modeling and neural ODEs for multiscale chaotic dynamics; the project resulted in a peer-reviewed article in *Chaos*.

Nordita Stockholm, Sweden
Undergraduate Thesis and Research Project Co-Supervisor Nov 2020–May 2022

- Co-supervised Nash Keyes (Yale University) on stochastic paleoclimatology and modeling of the EPICA ice-core climate record; the project resulted in a peer-reviewed article in *Chaos*.

Nordita Stockholm, Sweden
Undergraduate Thesis Co-Supervisor Mar 2020–Jun 2021

- Co-supervised Olle Bergström Jonsson (Stockholm University) on the prediction of rare events in multistable systems.

Pedagogical Training

Stockholm University, Faculty of Science Stockholm, Sweden
Higher-Education Teaching Course Autumn 2020

- Completed approximately 50 hours of training through the Department of Mathematics and Science Education and the Centre for the Advancement of University Teaching (CeUL), including lesson planning, peer feedback, classroom observation, and a reflective essay.

Honors and Awards

- John Söderbergs Scholarship, 2023–2024.
- Elisabeth och Herman Rhodins Scholarship, 2023–2024.
- L. Namowitskys Scholarship, 2022–2023.
- Kobbs Scholarship, 2022–2023.
- Geophysical Fluid Dynamics Fellowship, Woods Hole Oceanographic Institution, Summer 2022.
- SNIC/HPC2N Computational Grant, 60,000 core hours, 2021–2022.
- Smitts Scholarship, 2020–2021.
- C. F. Liljevalch Scholarship, 2020–2021.
- Path of Excellence Program, research project in number theory, Sapienza University of Rome, 2015–2016.

Academic Service

- Referee for *Physical Review Letters*, *Physical Review E*, *Physica D*, *IEEE Transactions on Information Theory*, *Philosophical Transactions of the Royal Society A*, *Journal of Chemical Physics*, and *Journal of Statistical Physics*.
- Ph.D. representative at Nordita, Nov 2020–Dec 2023.

Skills and Languages

- **Programming:** Python, Julia, MATLAB, C/C++, Mathematica, and LaTeX.
- **Languages:** Italian (native), English (C2), and German (B2).

Personal Interests

Transverse flute and cello; salsa, bachata, and tango; wine studies.