Dr. Joshua L. Pughe-Sanford

▶ youtube | ✉ email | 🏠 website | 𝔊 scholar

Applied mathematician working at the intersection of
dynamical systems theory and **interpretable AI**

EDUCATION

2023–Present	**Flatiron Institute**, *Center for Computational Neuroscience*
2017–2023	**Georgia Institute of Technology**, *Center for Nonlinear Science* Ph.D. in Physics | M.S. in Mathematics | GPA: 3.9
2013–2017	**Emory University** B.S. in Physics with Highest Honors | Minor in Mathematics | GPA: 3.9

PUBLICATIONS † *indicates co-first authorship*

J. L. Pughe-Sanford[†], A. Mah[†], S. Harvey, and A. Williams, "Linear approximations to HMM filtering," *submitted (ICML).*

F. Noah, **J. L. Pughe-Sanford**, and S. Grauer, "Degree-of-freedom and optimization dynamic effects on the observability of the kuramoto-sivashinsky model," *submitted (JCP).*

A. Ságodi, **J. L. Pughe-Sanford**, and D. Chklovskii, "The neuron as a feedback controller of stochastic dynamics," *submitted (L4DC).*

S. Qin, **J. L. Pughe-Sanford**, A. Genkin, P. G. Ozdil, P. Greengard, A. M. Sengupta, and D. Chklovskii, "A network of biologically inspired Rectified Spectral Units (ReSUs) learns hierarchical features without error backpropagation," *AAAI*, 2026.

J. L. Pughe-Sanford[†], X. Ding[†], J. J. Moore[†], C. Epstein, P. Greengard, A. M. Sengupta, and D. Chklovskii, "Neurons as Detectors of Coherent Sets in Sensory Dynamics," *NeurIPS*, 2025.

J. L. Pughe-Sanford, S. Quinn, T. Balabanski, and R. O. Grigoriev, "Computing chaotic time-averages from few periodic or non-periodic orbits," *Chaos*, 2025.

J. J. Moore, A. Genkin, M. Tournoy, **J. L. Pughe-Sanford**, R. R. de Ruyter van Steveninck, and D. B. Chklovskii, "The Neuron as a Direct Data-Driven Controller," *PNAS*, 2024.

J. L. Pughe-Sanford, "On the Generalization of Shadowing to Fluid Turbulence: Practical Methods For Quantifying Dynamical Similarity," Ph.D. Dissertation, Georgia Institute of Technology, 2023.

J. L. Pughe-Sanford[†], C. J. Crowley[†], W. Toler, R. O. Grigoriev, and M. F. Schatz, "Observing a dynamical skeleton of turbulence in Taylor–Couette flow experiments," *Philosophical Transactions of the Royal Society A*, 2023.

J. L. Pughe-Sanford[†], C. J. Crowley[†], W. Toler, M. C. Krygier, R. O. Grigoriev, and M. F. Schatz, "Turbulence tracks recurrent solutions," *PNAS*, 2022.

M. C. Krygier, **J. L. Pughe-Sanford**, and R. O. Grigoriev, "Exact coherent structures and shadowing in turbulent Taylor–Couette flow," *Journal of Fluid Mechanics*, 2021.

S. Boettcher and **J. L. Pughe-Sanford**, "Renormalization of Discrete-Time Quantum Walks with non-Grover Coins," *Journal of Statistical Mechanics: Theory and Experiment*, 2017.

J. L. Pughe-Sanford, "Properties of Quantum Walks within Various One-Dimensional Media," Honors Thesis, Emory University, 2017.

RECORDED TALKS

J. L. Pughe-Sanford, S. Quinn, L. L. Balabanski, and R. O. Grigoriev, "Computing Chaotic Time-Averages from a Small Number of Periodic Orbits." APS DFD, 2023 (abstract, recording)

J. L. Pughe-Sanford, and R. O. Grigoriev, "Vortex Interactions: a Low-Dimensional Approach to the Inverse Cascade." APS DFD, 2022 (abstract, recording)

J. L. Pughe-Sanford, and R. O. Grigoriev, "Heteroclinic Connections as Predictors of Extreme Events in Weakly Turbulent Flow." APS DFD, 2019 (abstract, recording)

AWARDS

Presidential Fellow, Georgia Institute of Technology | Herbert P. Haley Fellow | Phi Beta Kappa Honors Society

RESEARCH EXPERIENCE

Flatiron Institute, *with A. Williams and M. Chklovskii*   2023–2026

– **Derived error bounds** for recurrent neural network approximations to Bayesian filtering.
– **Implemented differentiable network architectures in JAX**
– **Derived Koopman-based models** for **optimal sensing and observability** in stochastic dynamical systems.
– **Derived control theoretic models** of neuronal function.
– **Mentored graduate researchers**, resulting in publications and postdoctoral placements.

Georgia Institute of Technology, *with R. Grigoriev*   2017–2023

– **Developed theory and numerical algorithms for forecasting chaotic dynamical systems** across short- and long-time horizons.
– **Built reduced-order models of turbulent flows** using coherent structures and invariant solutions of the Navier-Stokes equations.
– **Implemented simulation and analysis pipelines** in MATLAB and Python, including cluster-based workflows for high-dimensional nonlinear systems.
– **Mentored undergraduate researchers**, producing publications and graduate school placements.

Emory University, *with S. Boettcher*   2015–2017

– **Derived asymptotic scaling laws for quantum transport on graphs** and validated predictions via numerical simulations in Python and JAVA.
– **Analyzed computational complexity of quantum versus classical algorithms**, identifying regimes where quantum methods offer advantages.

Princeton University, *with F. Calaprice*   2013–2017

– **Designed and fabricated detector components** using AutoCAD and precision machining for dark matter experiments.

- **Assembled and deployed experimental detectors** at LNGS, ensuring operational success.
- **Optimized signal-to-noise** by improving polonium distillation efficiency.
- **Coordinated logistics and procurement** across collaborating teams to streamline assembly and operations.

Oxford College, *with R. Conceicao* 2013–2015

- **Investigated the Collatz conjecture and its polynomial variant**, deriving asymptotic approximations for total stopping time.

Work Experience

SciTech, *Princeton, NJ* 2023

- **Deployed digital twin simulations** for complex physical systems, producing production-ready code that met strict performance and reliability standards.
- **Applied CI/CD best practices** to automate workflows and ensure reproducibility.
- **Led benchmarking and optimization efforts**, reducing runtimes by **40×** and enabling high-throughput simulations.

B-Line Logic, *Atlanta, GA* 2014–2016

- **Led backend development** for an advanced logistics AI, delivering solutions for clients including **Delta Air Lines** and **Cardinal Health**.
- **Designed and implemented predictive analytics pipelines** for large-scale, distributed data systems.

Teaching Experience

Georgia Institute of Technology, *Atlanta, GA* 2017–2023

- **Promoted to lead TA**, training a team of **30** graduate TAs and designing introductory physics labs.
- **Delivered graduate lectures** in nonlinear dynamics and mathematical methods
- Received an average teaching evaluation of **4.9/5**.
- **Mentored undergraduates** and developed an online peer-support community to foster collaborative learning.

Service

2023–Present	**Diversity, Equity, and Inclusion Committee**, *Simons Foundation*
2020–2023	**Physics Allies for Wellness**, *Georgia Institute of Technology*
2018–2020	**Graduate Association of Physics**, *Georgia Institute of Technology*

Interests and Skills

Languages English, Spanish, Italian, German, MATLAB, Python
Hobbies Robotics, Video Game Development, Volleyball