Dr. Joshua L. Pughe-Sanford

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Education

2023-Present	**Flatiron Institute**, Center for Computational Neuroscience Flatiron Research Fellow (Post-Doc)
2017-2023	**Georgia Institute of Technology**, Center for Non-Linear Dynamics Ph.D. in Physics M.S. in Mathematics GPA: 3.9
2015-2017	**Emory University**, B.S. in Physics with Highest Honors (Summa Cum Laude) Minor in Mathematics GPA: 3.9
2013-2015	**Oxford College**, A.A. with Honors GPA: 3.9

Honors and Awards

2022	Herbert P. Haley Fellowship, Georgia Institute of Technology	$4,000
2022	Emelio Fellowship Nominee, Georgia Institute of Technology	
2022	Travel Grant, Georgia Institute of Technology	$1,000
2017-2021	Presidential Fellow, Georgia Institute of Technology	$20,000
2017-Present	Phi Beta Kappa, Honors Society	
2016	Travel Grant, Princeton University	$1,500
2016-Present	Sigma Phi Sigma, Physics Honors Society	
2015-Graduation	Dean's List, Emory University	
2013-Present	Phi Eta Sigma, National Honors Society	
2013-2015	Honors List, Oxford College	

Publications

† co-first authorship

P1. **J. L. Pughe-Sanford** and R. O. Grigoriev, "Point vortices predict extended vortex interactions in two-dimensional turbulence," *(in preparation)*

P2. **J. L. Pughe-Sanford**, S. Quinn, L. L. Balabanski, and R. O. Grigoriev, "Computing Chaotic Time-Averages from Few Periodic or Non-Periodic Orbits," *(submitted)*

P3. 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," 2024

P4. C. J. Crowley, **J. L. Pughe-Sanford**†, 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: Mathematical, Physical and Engineering Sciences, vol. 381, no. 2243, p. 20220137, 2023

P5. C. J. Crowley, **J. L. Pughe-Sanford**†, W. Toler, M. C. Krygier, R. O. Grigoriev, and M. F. Schatz, "Turbulence tracks recurrent solutions," *Proceedings of the National Academy of Sciences*, vol. 119, no. 34, p. e2120665119, 2022

P6. 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*, vol. 923, p. A7, 2021

P7. S. Boettcher and **J. L. Pughe-Sanford**, "Renormalization of Discrete-Time Quantum Walks with non-Grover Coins," *Journal of Statistical Mechanics: Theory and Experiment*, vol. 2018, p. 033103, 2017

P8. **J. L. Pughe-Sanford**, "Properties of Quantum Walks within Various One Dimensional Media," *Honors Thesis*, 2017

Conference Talks

C1. **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 Washington DC, 2023 (recorded)

C2. **J. L. Pughe-Sanford** and R. O. Grigoriev, "Vortex Interactions: a Low-Dimensional Approach to the Inverse Cascade." APS DFD Indianapolis, 2022 (recorded)

C3. W. Toler, C. J. Crowley, **J. L. Pughe-Sanford**, R. O. Grigoriev, and M. F. Schatz, "Simultaneous shadowing of multiple Exact Coherent Structures in experimental Taylor-Couette flow." APS DFD Indianapolis, 2022

C4. **J. L. Pughe-Sanford**, M. C. Krygier, and R. O. Grigoriev, "Can We Connect a Dynamical Description and a Statistical Description of Turbulence?." APS DFD Phoenix, 2021

C5. C. J. Crowley, **J. L. Pughe-Sanford**, W. Toler, R. O. Grigoriev, and M. F. Schatz, "Time evolution of turbulent Taylor-Couette flow is robustly captured by Exact Coherent Structures." APS DFD Phoenix, 2021

C6. W. Toler, C. J. Crowley, **J. L. Pughe-Sanford**, R. O. Grigoriev, and M. F. Schatz, "Transition to turbulence in experimental small-aspect Taylor-Couette flow." APS DFD Phoenix, 2021

C7. **J. L. Pughe-Sanford** and R. O. Grigoriev, "Dynamics and statistics of weakly turbulent Taylor-Couette flow in terms of exact coherent structures." APS DFD Chicago, 2020

C8. W. Toler, C. J. Crowley, **J. L. Pughe-Sanford**, K. Sands, M. F. Schatz, and R. O. Grigoriev, "Experimental tests of dynamical and statistical relevance of exact coherent structures in turbulent small-aspect-ratio Taylor-Couette flow." APS DFD Chicago, 2020

C9. C. J. Crowley, W. Toler, **J. L. Pughe-Sanford**, K. Sands, R. O. Grigoriev, and M. F. Schatz, "Identifying turbulent shadowing of 3D Exact Coherent Structures from measurements of 2D-2C velocity measurements in small-aspect-ratio Taylor-Couette flow." APS DFD Chicago, 2020

C10. **J. L. Pughe-Sanford** and R. O. Grigoriev, "Heteroclinic Connections as Predictors of Extreme Events in Weakly Turbulent Flow." APS DFD Seattle, 2019 (recorded)

C11. **J. L. Pughe-Sanford**, "Numerical Methods for Determining the Walk Dimension of Quantum Walks." Emory University SIRE Symposium, 2017

Teaching Experience

Georgia Institute of Technology

Advised undergraduate students *2020-2023*
- Resulted in publishable results for advisees.

Lectured Graduate Level Courses (not as TA) *2019, 2022*
- PHYS 7224, Non-Linear Dynamics
- PHYS 8823, Math Methods

Teaching Assistant *2017-2019*
- Earned 4.9/5.0 on my student teacher evaluations
- Was promoted to head TA; managed a team of TAs and taught them to effectively communicate material to students.
- Helped design an online forum where students could crowdsource help form peers and professors.

Service

Simons Foundation

Diversity, Equity, and Inclusion Committee *2024*

Georgia Institute of Technology

Physics Allies for Wellness (PAW) *2022*
- Founding member of an association that addresses social injustices and inequities in the physics department.

Graduate Association of Physics (GAP) *2017-2018*
- Led and coordinated Physics Forum, disseminating graduate research throughout specialties in the department.

Research Experience

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

Derived insightful models and decompositions of high-dimensional chaotic systems. My approaches often ground rigorous theoretical results within data-driven methods, balancing rigor and insight with methods that are practical.

- Developed expertise in numerical methods including quantitative data analysis, data visualization, non-linear optimization, statistical analysis, model simulation and machine learning.
- Produced groundbreaking results in forecasting extremal behavior.
- Constructed a predictive, 6-dimensional model of binary vortex interactions.
- Constructed dynamics and long-time statistics of chaotic systems using invariant sets.
- Created a fast numerical scheme for computing distances is systems with continuous symmetry.

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

Contrasted quantum dynamics over self-similar lattices with their classical analogs: random walks with memory. These investigations provide insight into how quantum algorithms (such as the Grover search algorithm) can traverse large data sets faster than their classical counterparts.

- Developed code suite for simulating, visualizing, and analyzing random and quantum walks.
- Derived novel results for quantum walks on the line.

- Used renormalization group to relate dynamics at different length scales.
- Derived a universality class of dynamics in certain lattice topologies.

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

Worked with Princeton's SABRE and Borexino collaborations, conducting experiments investigating the existence of dark matter candidate particles.

- Helped design and construct the SABRE scintillating-crystal detector and insertion system. Stringent specifications included hermeticity, chemical resistance, and precise control of the detector.
- Managed internal and external relations, sourcing materials and occasionally mediating conflicts.
- Optimized and automated polonium measurement techniques. Reported on the efficiency of distillation columns at the National Underground Laboratory at Gran Sasso, Italy.

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

Studied the Collatz conjecture, which is a dynamical system defined over positive integers *conjectured* but not proven to have a globally attracting fixed point at $x = 1$. I also studied a polynomial corollary of the Collatz conjecture.

- Well-approximated the total stopping time (i.e. iterations required to reach $x = 1$) for all monic polynomials in $(\mathbb{Z}/n\mathbb{Z})[x]$.

Work Experience

B-Line Logic, Atlanta, GA *2014-2016*

I was the lead backend engineer and developer for B-Line Logic, developing efficient AI-based tools for distilling Big Data into a small set of optimal actions plans.

- Created predictive-analytics engine for supply chain management.
- Developed a distributed event synchronization system.
- Managed relations with clients such as Delta Airlines and Cardinal Health.

Interests and Skills

Language (Native)	English
Language (Conversational)	Spanish, Italian
Coding Languages	Java, MATLAB, Python, Assembly, C++
Coding Skills	Machine Learning, big data, PDE simulation, objective function optimization, high-dimensional datasets, data visualization, pattern recognition
Robotics	Built a miniature self balancing, Segway-like robot piloted by an Arduino. Built a robotic hand that tracks the motion of a user-worn glove
Game Design	Created a 3D, single-player game with AI-controlled enemies