Juan Diego Toscano

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Education

Ph.D. in Applied Mathematics **2022 – Present**
Brown University, Providence, RI

- **Advisor:** Prof. George Karniadakis
- **Research Focus:** Developing reliable and stable scientific machine learning (SciML) methods to analyze and understand complex physical systems, and mathematics for agentic systems.

Sc.M. in Mechanical Engineering and Applied Mechanics **May 2026**
Brown University, Providence, RI

B.Eng. in Mechanical Engineering **2016 – 2021**
Universidad de las Fuerzas Armadas-ESPE, Ecuador

Biotechnology Engineering (Coursework) **2012 – 2016**
Universidad de las Fuerzas Armadas-ESPE, Ecuador

Research Experience

Academic Cooperation Program (ACP) Participant **Oct 2025 – Sep 2026**
Lawrence Livermore National Laboratory (LLNL), Livermore, CA (Remote)

- Participated in a collaborative program studying physics-informed neural network training methodologies and phase-transition metrics for model convergence.

Research Assistant, Doctorate **Jun 2023 – Present**
Brown University, Providence, RI

- **Mathematics for Agentic Systems and LLMs**: Developing mathematical foundations and LLM-based agentic frameworks (e.g., ATHENA, GRAFT-ATHENA) that autonomously diagnose, design, and evolve numerical algorithms for scientific discovery and computing.
- **Advanced Computational Modeling of Cerebrospinal Fluid Dynamics for Neuroscience Applications**: Developed novel physics-informed AI frameworks (e.g., AIV-NLL, MR-AIV) to reconstruct 3D brain-wide fluid flow fields from sparse experimental data.
- **Advances in Neural Network Architecture, Optimization, and Learning Theory**: Developed new network architectures (e.g., cKANs, KKANs) and optimization methods (e.g., RBA, RBAR, ssRBA) and explored representation models learning dynamics to improve the accuracy, efficiency, and theoretical understanding of deep learning models for scientific problems.
- **Generalization and Application of SciML Methods to Diverse Engineering and Physics Problems**: Demonstrated the broad applicability of my foundational methods by developing new techniques to analyze turbulence and model chemical reactors (e.g., AIVT, FMnets).

Fellowship, Doctorate **Sep 2022 – May 2023**
Brown University, Providence, RI

- Developed residual-based attention and adaptive training methods for physics-informed neural networks, and investigated their learning dynamics and generalization behavior.

External Research Collaborator **2019 – 2022**
University at Buffalo, Buffalo, NY

- Applied machine learning to model advanced manufacturing processes and implemented semi-supervised deep learning methods (GANs, RL) for 3D point cloud reconstruction.

Publications

*(*Denotes co-first authorship)*

1. **Toscano, J.D.**, Chai, Z., & Karniadakis, G.E. (2026). GRAFT-ATHENA: Self-Improving Agentic Teams for Autonomous Discovery and Evolutionary Numerical Algorithms. *arXiv preprint arXiv:2605.11117*.

2. **Toscano, J.D.**, Guo, Y., Wang, Z., Vaezi, M., Mori, Y., Karniadakis, G.E., et al. (2026). MR-AIV reveals *in vivo* brain-wide fluid flow with physics-informed AI. *Science Advances*, 12(22), eaeb0404. (Featured on the *Science Advances* homepage).

3. ***Toscano, J.D.**, *Chen, D.T., Oommen, V., Darbon, J., & Karniadakis, G.E. (2026). A variational framework for residual-based adaptivity in neural PDE solvers and operator learning. *NPJ Artificial Intelligence*, 2(1), 32.

4. Wang, Z., **Toscano, J.D.**, Guo, Y., Vaezi, M., Kelley, D.H., Karniadakis, G.E., et al. (2026). Data-Efficient Neural Operators Enable Brain-Wide Glymphatic Velocity Field Estimation from DCE-MRI. *TechRxiv*.

5. Vaezi, M., **Toscano, J.D.**, Guo, Y., Gomolka, R.S., Karniadakis, G.E., et al. (2026). Robust MR-AIV: A Systematic Study of Robustness Improvement and Sensitivity Analysis of MR-AIV. *bioRxiv*.

6. **Toscano, J.D.**, Chen, D.T., & Karniadakis, G.E. (2025). ATHENA: Agentic Team for Hierarchical Evolutionary Numerical Algorithms. *arXiv preprint arXiv:2512.03476*.

7. ***Toscano, J.D.**, *Oommen, V., *Varghese, A.J., et al. (2025). From PINNs to PIKANs: Recent advances in physics-informed machine learning. *Machine Learning for Computational Science and Engineering*, 1(1), 15.

8. ***Toscano, J.D.**, *Käufer, T., Wang, Z., et al. (2025). AIVT: Inference of turbulent thermal convection from measured 3D velocity data by physics-informed Kolmogorov-Arnold networks. *Science Advances*, 11(19), eads5236.

9. **Toscano, J.D.**, Wang, L.L., & Karniadakis, G.E. (2025). KKANs: Kurkova-Kolmogorov-Arnold Networks and Their Learning Dynamics. *Neural Networks*, 191, 107831.

10. Anagnostopoulos, S.J., **Toscano, J.D.**, Stergiopulos, N., & Karniadakis, G.E. (2025). Learning in PINNs: Phase transition, diffusion equilibrium, and generalization. *Neural Networks*, 107983.

11. Wu, C., **Toscano, J.D.**, Shukla, K., et al. (2025). FMEnets: Flow, Material, and Energy networks for non-ideal plug flow reactor design. *Chemical Engineering Science*, 122348.

12. Song, L., **Toscano, J.D.**, Wang, L. (2025). Explicit Construction of Approximate Kolmogorov-Arnold Superpositions with C^2-Smoothness. *arXiv preprint arXiv:2508.04392*.

13. *Shukla, K., ***Toscano, J.D.**, *Wang, Z., et al. (2024). A comprehensive and FAIR comparison between MLP and KAN representations for differential equations and operator networks. *Computer Methods in Applied Mechanics and Engineering*, 431, 117290.

14. *Anagnostopoulos, S.J., ***Toscano, J.D.**, Stergiopulos, N., & Karniadakis, G.E. (2024). Residual-based attention in physics-informed neural networks. *Computer Methods in Applied Mechanics and Engineering*, 421, 116805.

15. **Toscano, J.D.**, Wu, C., Ladrón-de-Guevara, A., et al. (2024). Inferring in vivo murine cerebrospinal fluid flow using artificial intelligence velocimetry with moving boundaries and uncertainty quantification. *Interface Focus*, 14(6), 20240030.

16. Zuniga-Navarrete, C., Segura, S. J., Baidya, S., **Toscano, J.D.**, et al. (2024). Electrospinning Process Modeling: A Multi-Stage View. *Proceedings of the International Manufacturing Science and Engineering Conference*.

17. **Toscano, J.D.**, Zuniga-Navarrete, C., Siu, W.D.J., et al. (2023). Teeth mold point cloud completion via data augmentation and hybrid RL-GAN. *Journal of Computing and Information Science in Engineering*, 23(4), 041008.

18. **Toscano, J.D.**, Hajifar, S., Segura, C.O., et al. (2021). Deformation analysis of 3d printed metacarpophalangeal and interphalangeal joints via transfer learning. *Proceedings of the International Manufacturing Science and Engineering Conference*.

19. **Toscano, J.D.**, Li, Z., Segura, L.J., & Sun, H. (2020). A machine learning approach to model the electrospinning process of biocompatible materials. *Proceedings of the International Manufacturing Science and Engineering Conference*.

Invited Talks

- **November 2026:** *"GRAFT-ATHENA: Self-Improving Agentic Teams for Autonomous Discovery and Evolutionary Numerical Algorithms"* (Upcoming). Minisymposium on Agentic AI for Scientific Discovery and Computing, **SIAM Conference on Mathematics of Data Science (MDS26)**, Salt Lake City, UT.
- **June 2026:** *"GRAFT-ATHENA: Self-Improving Agentic Teams for Autonomous Discovery and Evolutionary Numerical Algorithms"*. Monthly Online Seminar Series, **USACM Student Chapter (National)**.
- **May 2026:** *"ATHENA: Agentic Team for Hierarchical Evolutionary Numerical Algorithms"*. Hot Topics Workshop: Agentic Scientific Computing and Scientific Machine Learning, **ICERM, Brown University**.
- **February 2026:** *"ATHENA: Agentic Team for Hierarchical Evolutionary Numerical Algorithms"*. DAC WorkGroup on Scientific AI Agents Seminar, Department of Applied and Computational Mathematics and Statistics, **University of Notre Dame**.
- **2025:** *"Physics-informed Machine Learning: introduction, extensions and practical applications"*. Computational Mathematics + X Seminar, **California Institute of Technology (Caltech)**.
- **2025:** *"Physics-informed Machine Learning: introduction, extensions and practical applications"*. Center for Scientific Computing & Data Science Research, **University of Massachusetts Dartmouth**.
- **2024:** *"Inferring in vivo murine cerebrospinal fluid flow using artificial intelligence velocimetry with moving boundaries and uncertainty quantification"*. AI Medical Imaging (AIMI) Seminar, **The University of Texas at Austin**.

Conference Presentations

- **Nov. 2024:** Oral Contributed Speaker, *"Kolmogorov Artificial Intelligence Velocimetry infers hidden temperature from turbulent experimental velocity data"*. Session: Experimental Techniques: Pressure / Temperature. **APS Division of Fluid Dynamics Meeting**.
- **Nov. 2023:** Oral Contributed Speaker, *"ALAIV: Assessing Lymphatic Flows through Artificial Intelligence Velocimetry"*. Session: Biofluids: Lymphatic and CSF Flows I. **APS Division of Fluid Dynamics Meeting**.
- **Oct. 2023:** Oral Contributed Speaker, *"Adaptive AIV: Reconstructing Velocity and Pressure Fields from In-Vivo Data with Moving Boundary Conditions"*. **Advances in Computational Mechanics**.
- **June 2021:** Oral Contributed Speaker, *"Deformation Analysis of 3D Printed Metacarpophalangeal and Interphalangeal Joints via Transfer Learning"*. **Manufacturing Science and Engineering Conference (MSEC)**.

Professional Service: Peer Review

- **Journal of Computational Physics** (18 reviews)
- **Computer Methods in Applied Mechanics and Engineering** (4 reviews)
- **Neural Networks** (3 reviews)
- **Nature Communications** (2 reviews)
- **Physics of Fluids** (2 reviews)
- **Physica A: Statistical Mechanics and its Applications** (2 reviews)
- **SISC's Machine Learning Methods for Scientific Computing section** (2 reviews)
- **Science Advances** (1 review)
- **Physical Review E** (1 review)
- **Physical Review Research** (1 review)
- **International Journal of Computational Intelligence Systems** (1 review)
- **Expert Systems with Applications** (1 review)
- **Communications in Nonlinear Science and Numerical Simulation** (1 review)

Professional Memberships

- Member, American Society of Mechanical Engineers (ASME)
- Student Member, Society for Industrial and Applied Mathematics (SIAM)
- Student Member, American Physical Society (APS)

Honors and Awards

- TU Ilmenau Publication Award, Mathematics and Natural Sciences (AIVT author team) 2026
- Doctorate Fellowship, Brown Graduate School, Brown University 2023
- Doctorate Fellowship, Brown Graduate School, Brown University 2022
- Valedictorian, Department of Mechanics Sciences and Engineering, ESPE 2021
- Academic Excellence Scholarship, Universidad de las Fuerzas Armadas-ESPE 2018
- Academic Distinction Scholarship, Universidad de las Fuerzas Armadas-ESPE 2017

Skills

- **Languages:** Spanish (Native), English (Advanced), Chinese (Basic).
- **Programming:** Python, MATLAB, R, Julia, Swift, C.
- **Software & Technologies:** 3D-Printing and Modeling (SolidWorks, Inventor, Fusion 360), App Development (XCode).

Leadership & Scientific Outreach

- **Seminar Organizer:** Organizer for the weekly Crunch Seminar series at Brown University.
- **Scientific Communication:** Creator and instructor for the "Juan Toscano" YouTube channel, which has over 1,870 subscribers. The associated public GitHub repository has over 671 stars and 203 forks, and receives more than 1000 visits per week.
- **University Leadership:** Chess-Club President, Universidad de las Fuerzas Armadas-ESPE (2018-2019).
- **Hobbies:** Cycling, playing the piano, singing, and reading.