TYLER W. HUGHES

Differentiable Simulation · Inverse Design · Agentic Systems for Science

Head of Photonics · Flexcompute Inc. · New York, NY

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ABOUT

I build physics simulation software that engineers (and increasingly, AI agents) use to design real hardware.

EXPERIENCE

Head of Photonics Sep 2019 – present

Flexcompute Inc. · www.flexcompute.com

Research Scientist (2019–2024) → Principal Scientist (2024–2025) → Head of Photonics (2025–)

- Lead a team of several dozen scientists and engineers driving the company's electromagnetic simulation products and physics solvers, while staying hands-on in code and research.
- Architected and built the Python client for Tidy3D (330★), a commercial cloud physics simulator used daily across the semiconductor, photonics, and RF industries. Defined the API, data model, and user experience that most users interact with through Python.
- Built the differentiable simulation platform that lets users optimize hardware designs with gradient descent over high-dimensional parameter spaces (millions or more), the same technique as training a neural network, applied to physical devices.
- Current product focus: exploring how AI agents, combined with tools like MCP, can drive automated simulation and design workflows; write-up.

Graduate Research Assistant Sep 2014 – Aug 2019

Stanford University, Shanhui Fan Group · web.stanford.edu/group/fan/

- Pioneered methods for using photonic hardware to do analog machine learning: optical backpropagation, wave-based recurrent neural networks, and nonlinear optical activation functions.
- Developed and open-sourced tooling for differentiable electromagnetic simulation and adjoint-based photonic inverse design (ceviche, angler, wavetorch).

Machine Learning Intern Jun – Sep 2018

Rasa Technologies · rasa.com/

- Researched text understanding via named-entity recognition; implemented lookup-table matching as a major open-source feature in the Rasa NLU framework.

Junior Software Engineer Jan – Aug 2014

GudTech Inc.

- Full-stack engineering for commercial inventory management software.

EDUCATION

PhD & MS, Applied Physics Sep 2014 – Aug 2019

Stanford University

Thesis: *Adjoint-Based Optimization and Inverse Design of Photonic Devices* · Advisor: Prof. Shanhui Fan

BS, Physics, With Distinction and Highest Honors Sep 2009 – May 2013

University of Michigan

Thesis: *Wafer Reuse for Low-Cost, Thin-Film III–V Photovoltaic Devices* · Advisor: Prof. Stephen Forrest

SELECTED PUBLICATIONS

Hughes, T. et al. *Wave physics as an analog recurrent neural network.* **Science Advances** (2019).
Pai, S., Sun, Z., **Hughes, T.** et al. *Experimentally realized in-situ backpropagation for deep learning in nanophotonic neural networks.* **Science** (2023).
Hughes, T. et al. *Training of photonic neural networks through in-situ backpropagation.* **Optica** (2018).
Hughes, T. et al. *Forward-mode differentiation of Maxwell's equations.* **ACS Photonics** (2019).
Hughes, T. et al. *Adjoint method and inverse design for nonlinear nanophotonic devices.* **ACS Photonics** (2018).
Yamilov, A., Skipetrov, S. E., **Hughes, T.** et al. *Anderson localization of electromagnetic waves in three dimensions.* **Nature Physics** (2023).

3,777 citations · h-index 23 · 9 first-author publications (as of April 2026) · full list.

WRITING

Can AI agents autonomously design components on photonic chips?, Flexcompute Engineering (2026). AI agents equipped with an electromagnetics simulator tackle waveguide bends, crossings, splitters, and demultiplexers through iterative simulation.
Designing a photonic chip component with ∼45 lines of Python, Flexcompute Engineering (2026). Compact introduction to photonic inverse design using Tidy3D and the adjoint method.

SELECTED PATENTS

Efficient Analog Backpropagation Training Architecture for Photonic Neural Networks (2023).
Simultaneous Measurements of Gradients in Optical Networks (2022).
Training Wave-Based Physical Systems as Recurrent Neural Networks (2022).
Systems and Methods for Activation Functions for Photonic Neural Networks (2022).
Training of Photonic Neural Networks Through In-Situ Backpropagation (2021).

OPEN SOURCE

tidy3d	GPU-accelerated 3D electromagnetics solver with cloud execution and full autodiff.	330★
ceviche	Differentiable frequency-domain electromagnetic simulation (FDFD), JAX/autograd-compatible.	409★
angler	Adjoint-based inverse design for nonlinear nanophotonic devices.	189★
wavetorch	Wave-based analog RNN simulator; physics ↔ RNN correspondence.	541★
neuroptica	Optical neural network hardware simulation with physical imperfections.	269★

SELECTED INVITED TALKS

Building the future of photonic design with machine learning, Frontiers in Optics, Visionary Speaker (2025).
Hardware-accelerated FDTD for large-scale electrodynamics, UW Madison Computing in Engineering Forum (2022).
Training of photonic neural networks through in-situ backpropagation, CLEO (2019).