

# TYLER W. HUGHES

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## ABOUT

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I am a computational physicist working at the intersection of photonics, machine learning, and scientific software. My work focuses on differentiable electromagnetic simulation, adjoint-based optimization, and wave-based machine learning. I design and implement large-scale simulation systems (GPU-accelerated FDTD/FDFD), develop numerical optimization methods, and build software frameworks enabling gradient-based design of photonic structures.

## EDUCATION

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**PhD and MS, Applied Physics** Sept 2014 – Aug 2019  
Stanford University  
Thesis: *Adjoint-Based Optimization and Inverse Design of Photonic Devices*  
Advisor: Prof. Shanhui Fan

**Bachelor of Science, Physics** (With Distinction and Highest Honors) Sept 2009 – May 2013  
University of Michigan  
Thesis: *Wafer Reuse for Low Cost, Thin Film III-V Photovoltaic Devices*  
Advisor: Prof. Stephen Forrest

## SELECTED WORK EXPERIENCE

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**Research Scientist → Principal Scientist → Head of Photonics** Sept 2019 – present  
*Flexcompute Inc* [flexcompute.com](http://flexcompute.com)

- Technical lead for large-scale electromagnetic simulation systems, including GPU-accelerated solvers, distributed compute infrastructure, and differentiable simulation frameworks.
- Architected the Tidy3D API and Python client, defining abstractions for simulation setup, data flow, parallel execution, and cloud/HPC integration.
- Designed the automatic-differentiation stack enabling high-dimensional inverse design and gradient-based optimization of photonic devices.
- Developed adjoint formulations, numerical methods, and optimization techniques used across industry and academia for differentiable EM simulations.
- Collaborated closely with research, engineering, and product teams to translate advances in computational electromagnetics into scalable, production-ready tools.

**Graduate Research Assistant** Sept 2014 – Aug 2019  
*Stanford University Shanhui Fan Group* [web.stanford.edu/group/fan](http://web.stanford.edu/group/fan)

- Invented approaches for analog machine learning with photonic hardware, including optical backpropagation, analog recurrent neural networks, and nonlinear optical activation functions.
- Developed extensions to the adjoint method for photonic device optimization; released open-source tools demonstrating differentiable simulation for photonics.

**Machine Learning Intern** Jun 2018 – Sept 2018  
*Rasa Technologies* [rasa.com](http://rasa.com)

- Researched text understanding via named-entity recognition. Implemented a major open-source feature enabling lookup table matching.

**Junior Software Engineer** Jan 2014 – Aug 2014  
*GudTech Inc.* [gudtech.com](http://gudtech.com)

- Full-stack development for commercial inventory management systems; implemented multidimensional data analysis tools.

## SELECTED PUBLICATIONS

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- Pai, S., Sun, Z., **Hughes, T.** et al. *Experimentally realized in situ backpropagation for deep learning in nanophotonic neural networks*. Science (2023).
- Yamilov, A., Skipetrov, S.E., **Hughes, T.** et al. *Anderson localization of electromagnetic waves in three dimensions*. Nature Physics (2023).
- Hughes, T.** et al. *Training of photonic neural networks through in situ backpropagation*. Optica (2018).
- Hughes, T.** et al. *Wave physics as an analog recurrent neural network*. Science Advances (2019).
- Hughes, T.** et al. *Forward-mode differentiation of Maxwells equations*. ACS Photonics (2019).
- Hughes, T.** et al. *Adjoint method and inverse design for nonlinear nanophotonic devices*. ACS Photonics (2018).
- Hughes, T.** et al. *A perspective on the pathway toward full-wave simulation of large-area metalenses*. APL (2021).
- Hughes, T.**, Fan, S. *Plasmonic circuit theory for multiresonant light funneling*. Nano Letters (2016).
- Hughes, T.** et al. *Reconfigurable photonic circuit for controlled power delivery to DLAs*. Physical Review Applied (2019).
- Hughes, T.** et al. *On-chip laser power delivery for dielectric laser accelerators*. Physical Review Applied (2018).

## SELECTED PATENTS

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- *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).

## SKILLS

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<b>Programming</b>	Python, C/C++, Julia.
<b>Frameworks</b>	JAX, PyTorch, Autograd, Scientific Python (NumPy, SciPy, xarray).
<b>Domains</b>	Electromagnetic simulation (FDTD/FDFD), differentiable physics, inverse design, optimization.

## OPEN SOURCE PROJECTS

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<b>Tidy3D</b>	GPU-accelerated Maxwell's Equations solver.	<a href="#">link</a>
<b>Cevice</b>	Differentiable frequency-domain electromagnetic simulation.	<a href="#">link</a>
<b>Wavetorch</b>	Wave-based analog RNN simulator and trainer.	<a href="#">link</a>
<b>Angler</b>	Inverse-design tool for nonlinear optics.	<a href="#">link</a>
<b>Symbolic Regression</b>	ML tool for discovering analytic expressions.	<a href="#">link</a>
<b>Neuroptica</b>	Optical neural network hardware modeling framework.	<a href="#">link</a>
<b>Rasa</b>	ML framework for natural language understanding.	<a href="#">link</a>

## SELECTED INVITED TALKS

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

## LINKS

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<b>Personal Website</b>	<a href="https://twhughes.github.io">twhughes.github.io</a>
<b>Google Scholar</b>	<a href="https://scholar.google.com/citations?user=-AHhToYAAAAJ">scholar.google.com/citations?user=-AHhToYAAAAJ</a>
<b>Github</b>	<a href="https://github.com/twhughes">github.com/twhughes</a>
<b>LinkedIn</b>	<a href="https://linkedin.com/in/tylerwhughes">linkedin.com/in/tylerwhughes</a>