

Blake Wilson

**Ph.D. Student at Purdue
University, Research Consultant
at QuEra Computing**

06 August 2023

Contact Information

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<https://github.com/Btrainwilson>
NanoML:
<https://nanometaml.github.io>

I love leading students to succeed in research and developing new connections between mathematics, physics, and computer science. I've been able to reach hundreds of new researchers through the Quantum Science Center at Oak Ridge National Lab and the ECE department at Purdue University. My current research is focused on the development of new information geometry inspired neural networks, Bayesian quantum optimization on neutral atoms, designing meta-lenses for optical trapping of Rydberg atoms and the demonstration of generative adversarial modeling for tampering detection in cryptographic plasmonic systems.

Education

Ph.D. Electrical and Computer Engineering | Purdue University | 2019 – May 2024

- **GPA:** 3.6
- **Focus:** Quantum Machine Learning and Generative Models for Engineering
- **Advisors:** Alexandra Boltasseva, Sabre Kais, Vladimir Shalaev, and Alexander Kildishev

B.S. Computer Engineering | Purdue University | 2015 – 2019

- **GPA:** 3.4
- **Minor:** Philosophy
- **Focus:** Algorithms for Multi-Agent Systems and VLSI

Relevant Experience

Research Consultant | QuEra Computing, Cambridge, MA | 2022 – Current

- Developing generative model applications and Bayesian optimization for Rydberg atom quantum computer.
- Designing and testing unsupervised geometric neural networks for mapping metric spaces with applications in information geometry.
- Applying machine learning for the optimization of a hyperbolic metalens for the trapping of Rydberg atoms.
- Proved that optimization of pseudo-Boolean surrogate functions constructed by the low-degree algorithm cannot exceed the sampled set.

Research Assistant | Purdue University, West Lafayette, IN | 2016 – Current

- Proved the undecidability of simulation properties between a simulation and its simulator. These undecidability results prove that the simulation hypothesis is undecidable, quantum mechanics can be simulated by a classical computer using special relativistic simulation properties, and artificial intelligence cannot prove it is simulated [1].
- Developed a sampling algorithm for designing the topology of nanophotonic devices by sampling the latent space of a variational autoencoder via a factorization machine surrogate model. The ML algorithm can generate 500 thermal emitter designs in 30 minutes while state of the art, non-ML based algorithms take several hours to days for similar efficiencies. [2]
- Created a new vertex-separator that generalizes the Catalan Numbers and proved its generating function in infinite δ -ary trees. [5]
- Built and integrated scientific packages (S4, D-Wave Leap, Quantum Monte-Carlo) with Cloud API's, Python, MATLAB, and C/C++ for implementing my team's research projects.

Graduate Software Engineering Intern | Arm, Austin, TX | Summer 2019

- Improved ARMv8 verification self-test reproducibility and the Chi-Square distribution of ARM's software verification suite RNG from 0.2 to 0.5 by restructuring the RNG seeding.
- Wrote Python scripts to compare the coverage of ARMv8 self-tests generated by various C++ RNG's.
- Rebuilt 2 ARMv8 self-test directives to reduce the complexity of debug self-tests.

Skills

Proficient

Machine Learning | Scientific Software Engineering (Python, C/C++, MATLAB, VCS) | Quantum Computing and Quantum Information | Optimization Algorithms | Theoretical Computer Science | Electrodynamics and Nanophotonics

Familiar

Relativistic Physics | Information Geometry | Topological Quantum Systems | Numerical Methods

Relevant Coursework

- ECE695 – Generative Models
- IE 561 – Convex Optimization (Proofs of asymptotic bounds on convergence of GD algorithms)
- MA 525 – Complex Analysis (Residue Theorems)
- ECE695 – Quantum Signal Processing (Fock Spaces, Rabi Oscillations, Dyadic Greens Functions)
- PHYS526 – Quantum Computing (Gate model algorithms, Adiabatic, Topological)
- ECE595 – Deep Learning (Python, PyTorch, Convolutional Neural Networks, Theory)

Publications

1. **__ A __ Relative Church-Turing-Deutsch Thesis from Special Relativity and Undecidability __**, B. Wilson, E. Dickey, V. Iyer, S. Kais, **In Peer-Review**, Preprint: arXiv:2206.06419
2. **Machine Learning Framework for Quantum Sampling of Highly-Constrained, Continuous Optimization Problems**, B. Wilson, Z. Kudyshev, et al. , Applied Physics Reviews 8, 041418 (Impact Factor 19.16)
3. **Planning for Package Deliveries in Risky Environments Over Multiple Epochs**, B. Wilson, J. Hudack, S. Sundaram, arXiv:2110.09917 [math.OC], ACC 2022
4. **Metasurface Design Optimization via D-Wave based Sampling**, B. Wilson, Z. Kudyshev, et al. , CLEO2021

5. **Bounds on Sweep-Covers by Raney Numbers**, B. Wilson, arXiv:2009.08549 [math.CO]
6. **Multiple Pursuers Under Partial Information from Sensors**, B. Wilson, A. Prasad, S. Sundaram www.blakewilson.org/publications

Presentations

1. **Empowering Quantum 2.0 Devices and Approaches with Machine Learning (QTu2A.13)**, B. Wilson, Y. Chen, et al. , Quantum 2.0
2. **Source Shaping for Electromagnetic Optimization via Higher-Order Variational Quantum Algorithms**, B. Wilson, V. Mhiktaryan, et al., Quantum Science Center 2nd Annual Summer School Poster Session (2022)
3. **Machine Learning for Nanophotonic Design and Quantum Measurements**, B. Wilson, Y. Chen, et al. – Purdue Elmore Center (2021)
4. **Metasurface Compression Analysis via bVAE Reconstruction Loss**, V. Iyer, B. Wilson, et al., ECE Elmore Emerging Frontiers Center Poster Session (2022)
5. **QUBO Sampling of Highly-Constrained Optimization Problems: Inverse Design of Metasurfaces**, B. Wilson, Z. Kudyshev, et al., QSC PGA Poster Session 2021
6. **AFTx04 Design and Tapeout**, M. Singhal, J. Stevens, et al. Microelectronics Integrity Meeting NSWC Crane (2018)

Software Engineering Projects

PyExLab Python Package | Role: Lead Developer | 2022 – Current

- Python package for data management and running abstract experiments in Python environments.
- Source Code: <https://github.com/Btrainwilson/pyexlab>

PyExML Python Package | Role: Lead Developer | 2022 – Current

- Extension of PyExLab to manage PyTorch machine learning experiments.
- Source Code: <https://github.com/Btrainwilson/pyexml>

Lumenodes Marching Band Lights | Role: Firmware Engineer | 2019

- Developed the firmware for controlling a set of synchronized RGB uniform marching band lights for the Purdue All-American Marching Band.
- Project Link: <https://www.blakewilson.org/lumenodes>

Outreach and Leadership

QSC Postdoctoral and Graduate Student Association | Team Lead | 2021 – Current

- Lead a team of 10 postdoctoral researchers and graduate students to provide regular career development and networking events to the quantum science center by exposing students to leaders in industry (e.g., IBM Quantum, JPMorgan Chase, ColdQuanta, QuEra, Google), academia, (e.g., Harvard, MIT, Purdue, Technion) and national labs (e.g., Oak Ridge National Lab, Fermilab).
- Planned and executed the 2nd Annual QSC Summer School at Purdue University, a four day quantum conference with over 120 participants and several distinguished speakers from academia, industry, and national labs.

Nanophotonics Machine Learning Lab | Team Lead | 2021 - Current

- Lead a team of graduate researchers to develop machine learning algorithms for improving applications in nanophotonics, e.g., meta-optics design, fabrication, characterization and measurement.
- Developed PyExLab and PyExML python packages to assist teammates with designing machine learning experiments.

Summer Undergraduate Research Fellowship | Graduate Mentor | Summer 2020

- Mentored a group of 20 undergraduate researchers to execute a research project from start to finish and guided their career development throughout the summer.
- Due to the overtime I spent mentoring students, my group won the most awards during the SURF 2020 symposium and several students went on to become Ph.D. students at top universities like Cornell, Johns Hopkins, Purdue University, etc., and publish their work in top journals and conferences.

Stories of Success Fireside Chats | Host | 2019 - 2020

- Hosted monthly fireside chats with Purdue ECE alumni to give high school and undergraduate students opportunities to learn from successful alumni.

System-On-Chip Software Team Lead | Purdue University SOC Team | 2018 – 2019

- Tasked to lead a team to generate bootup code and a ROM module in 3 months for running startup tests in a custom 90nm RISC-V System-on-Chip (SOC) fabricated at MIT Lincoln Labs, the AFTx04.
- Developed a Python tool to compile C code into RISC-V machine code and onboard the machine code into a Verilog ROM module compatible with the SOC protocols.
- After finishing the ROM module early, I fixed critical bugs in the system-on-chip from source code to netlist level. This work directly led to the team's first completely functional SOC and led to future research projects, including integrated machine learning projects, and more funding for the next version of the chip.
- Developed test vectors for verifying the SOC with NSWC Crane and MIT-Lincoln Lab engineers.

Extended Experience

Research Consultant	QuEra Computing, Cambridge, MA	May 2022 - Current
Graduate Research Assistant	Purdue University, West Lafayette, IN	May 2020 - Current
Team Lead PGA	Quantum Science Center, ORNL	May 2021 - 2022
Graduate Teaching Assistant (ECE 368)	Purdue University, West Lafayette, IN	Summer 2021
Graduate Research Assistant (Shreyas Sundaram)	Purdue University, West Lafayette, IN	Spring 2021
Graduate Teaching Assistant (ECE 264)	Purdue University, West Lafayette, IN	Fall 2020
SURF Graduate Assistant	Purdue University, West Lafayette, IN	Summer 2020
ECE Shop Graduate TA	Purdue University, West Lafayette, IN	Fall 2019 - 2020
Verification Software Engineering Intern	ARM, Austin, TX	Summer 2019
System on Chip Software Team Lead	Purdue University, West Lafayette, IN	2018-2019
SURF Fellow	Purdue University, West Lafayette, IN	2017

Research Consultant	QuEra Computing, Cambridge, MA	May 2022 - Current
Resident Assistant	Purdue University, West Lafayette, IN	2016-2018

) Awards

Fellowships

Summer Undergraduate Research Fellowship	Purdue University	Summer 2017
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Grants

AWS Braket Research Grant	Amazon	2023 - 2024
Universities Space Research Association Quantum (Cycle 4)	NASA Ames Center	Nov. 2020 – 2021
Leadership Computing Facility D-Wave	Oak Ridge National Lab	Mar. – Sep. 2020

Competitions

2nd Place - National Rube Goldberg Competition	Purdue University	Feb. 2016
3rd Place – IUPUI Mathematics Competition	IUPUI	Spring 2014

Affiliations

QuEra Computing	Harvard/MIT	May 2022 - Current
Quantum Science Center	Oak Ridge National Lab	Aug. 2020 - Current
Elmore Emerging Frontiers Center	Purdue University	Aug. 2020 - Current
Purdue Quantum Science and Engineering Institute	Purdue University	Aug. 2019 - Current
IEEE Computer Society	IEEE	Aug. 2020 - 2021
Purdue Society of Professional Engineers	Purdue University	Aug. 2015 – May 2016

References

Sabre Kais	kais@purdue.edu	765-494-5965
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Alexander Kildishev	kildisha@purdue.edu	765-496-3196
Shreyas Sundaram	sundara2@purdue.edu	765-496-0406