Ben Bartlett, Ph.D.

Physicist specializing in programmable photonics, quantum information, and software engineering

Contact

803.238.8594
benjamincbartlett@gmail.com
bencbartlett.com
Google Scholar - Ben Bartlett
twitter.com/bencbartlett
github.com/bencbartlett

Education

Ph.D. Applied Physics • **Stanford University** • 2017 – 2022
Dissertation: *Photonic computing architectures for classical and quantum information processing* [link]
Advisor: Shanhui Fan
Research interests: optical computing, machine learning, quantum information, nanophotonics

M.S. Electrical Engineering • **Stanford University** • 2019 – 2022
Focus: quantum technologies, photonics, machine learning (advised by Shanhui Fan)

B.S. Physics + Computer Science • **California Institute of Technology** • 2013 – 2017
Focus: computational physics, particle physics, quantum information (advised by Maria Spiropúlu)

Employment

PsiQuantum • Palo Alto, CA • 2022 – present
Quantum computer architect
System architecture team, designing a scalable and fault-tolerant photonic quantum computer

X Development *(formerly Google X)* • Mountain View, CA • 2021 – 2022
Ph.D. residency, undisclosed project
Research involving electromagnetics, machine learning, and high-performance distributed computing

Stanford Pre-Collegiate Studies • Stanford, CA • 2019
Physics instructor
Designed and taught a course for advanced students covering a broad range of physics topics

AT&T Foundry / INQNET • Palo Alto, CA • 2017
Engineering, quantum networks
Developed a parallelized quantum network simulator for communication over noisy quantum channels

SLAC National Accelerator Lab • Menlo Park, CA • 2016
Engineering intern, Technology Innovation Directorate
Wrote the functional testing suite for camera readout boards on the Large Synoptic Survey Telescope

CERN • Geneva, Switzerland • 2015 – 2016
Undergraduate researcher, Compact Muon Solenoid
Developed a vertex reconstruction algorithm for the CMS detector, improving resolution by ~160×

California Institute of Technology • Pasadena, CA • 2014 – 2016
Undergraduate researcher, geophysics
Rotational stabilization during the Precambrian era due to resonant thermally-driven tidal interactions

Skills

Programming:	*Fluent:*	Python, Mathematica, TypeScript, NumPy/SciPy, Matplotlib, LaTeX
	Experienced:	PyTorch, TensorFlow, JavaScript, GLSL, QuTiP, Meep
	Familiar:	C++, C, Julia, rllib, ray
	Passable:	Haskell, Visual Basic, Bash, MATLAB, Kotlin
Software:		Blender, Ableton Live, AutoCAD, Autodesk Inventor, Adobe Illustrator / InDesign / Photoshop / Premiere / Audition, Final Cut Pro, ffmpeg, LyX, Sphinx, Doxygen, TypeDoc
Design:		scientific visualization and animation *[portfolio]*, graphic design, generative art, vector graphics, music production, sound design
Laboratory:		nanofabrication, optical lithography, free-space optics, high-vacuum systems

Patents

1. B. Bartlett, A. Dutt, and S. Fan, "A scalable design for a photonic quantum computer using a fiber ring and a single coherently controlled atom", US Patent Application 63/087,661, Stanford OTL #20-399 (2020)
2. B. Bartlett, A. Dutt, and S. Fan, "Systems and methods for deterministic photonic quantum computing in a synthetic time dimension", International Publication Number WO2022076982A1 (2021) [link]

Press coverage

1. "Learning photons go backward" – Science
2. "Stanford engineers propose a simpler design for quantum computers" – Stanford News
3. "Researchers propose a simpler design for quantum computers" – phys.org
4. "Photonic chips curb AI training's energy appetite" – IEEE Spectrum
5. "Photonic neural network chip makes calculations a breeze" – Laser Focus World
6. "A simpler design for quantum computers" – EurekAlert
7. "Stanford's simple new quantum computer design: photonic computation in a synthetic time dimension" – SciTechDaily
8. "A new, simpler quantum computer" – Interesting Engineering
9. "Sequence of operations simplifies photonic quantum computers" – photonics.com

Publications

1. S. Pai, Z. Sun, T.W. Hughes, T. Park, B. Bartlett, I.A.D. Williamson, M. Minkov, M. Milanizadeh, N. Abebe, F. Morichetti, A. Melloni, S. Fan, O. Solgaard, and D.A.B. Miller, "Experimentally realized in situ backpropagation for deep learning in photonic neural networks", ***Science***, 380, 398-404 (2023) [link] [press coverage]
2. B. Bartlett, O.Y. Long, A. Dutt, and S. Fan, "Programmable photonic system for quantum simulation in arbitrary topologies", *arXiv: 2211.09805 [quant-ph]* (2022) [link]
3. S. Pai, T.W. Hughes, T. Park, B. Bartlett, I.A.D. Williamson, M. Minkov, M. Milanizadeh, N. Abebe, F. Morichetti, A. Melloni, O. Solgaard, S. Fan, and D.A.B. Miller, "Inference and Gradient Measurement for Backpropagation in Photonic Neural Networks", *Conference on Lasers and Electro-Optics, OSA Technical Digest*, (2022) [link]
4. B. Bartlett, A. Dutt, and S. Fan, "Deterministic photonic quantum computation in a synthetic time dimension", ***Optica***, 8, 1515-1523 (2021) [link] [press coverage]
5. B. Bartlett, A. Dutt, and S. Fan, "Teleportation-based photonic quantum computing using a single controllable qubit", *Conference on Lasers and Electro-Optics, OSA Technical Digest*, FTh2N.3 (2021) [link]
6. B. Bartlett and S. Fan, "Photonic quantum programmable gate arrays", *Conference on Lasers and Electro-Optics, OSA Technical Digest*, JM4G.8 (2020) [link]
7. I.A.D. Williamson, T.W. Hughes, M. Minkov, B. Bartlett and S. Fan, "Tunable nonlinear activation functions for optical neural networks", *Conference on Lasers and Electro-Optics, OSA Technical Digest*, SM1E.2 (2020) [link]
8. B. Bartlett and S. Fan, "Universal programmable photonic architecture for quantum information processing", *Physical Review A,* 101, 042319 (2020) [link]
9. M.M.P. Fard, I.A.D. Williamson, M. Edwards, K. Liu, S. Pai, B. Bartlett, M. Minkov, T.W. Hughes, S. Fan, and T. Nguyen, "Experimental realization of arbitrary activation functions for optical neural networks", *Optics Express*, 28, 12138-12148 (2020) [link]
10. I.A.D. Williamson, T.W. Hughes, M. Minkov, B. Bartlett, S. Pai, and S. Fan, "Reprogrammable Electro-Optic Nonlinear Activation Functions for Optical Neural Networks" *[Invited paper]*, *IEEE Journal of Selected Topics in Quantum Electronics*, 26 (1), 1-12 (2019) [link]
11. S. Pai, B. Bartlett, O. Solgaard, and D.A.B. Miller (2019), "Matrix optimization on universal unitary photonic devices", *Physical Review Applied*, 11, 064044 (2019) [link]
12. B. Bartlett, "A distributed simulation framework for quantum networks and channels", *arXiv:1808.07047 [quant-ph]* (2018) [link]
13. B.C. Bartlett, and D.J. Stevenson, "Analysis of a Precambrian resonance-stabilized day length", *Geophysical Research Letters*, 43, 5716-5724 (2016) [link]
14. B. Bartlett, L. Gray, A. Bornheim, and M. Spiropulu, "Time-based vertex reconstruction in the Compact Muon Solenoid", *CMS Analysis Note*, CMS AN -2016/367 (2015) [link]

Presentations

1. "Architectures for deterministic photonic quantum computers using strongly-coupled quantum emitters" *[Invited]*, University of Stuttgart Physics Seminar Series, November 2021

2. “Teleportation-based photonic quantum computing using a single controllable qubit”, CLEO 2021: Photonic Computing, May 2021
3. “A photonic quantum computer design with only one controllable qubit” *[Invited]*, Stanford Q-FARM Seminar Series, April 2021
4. “How to train your photons: adventures in optical machine learning” *[Invited]*, QHACK 2021, February 2021
5. “Photonic quantum programmable gate arrays”, CLEO 2020: Photonic NISQ Technologies, May 2020
6. “Universal programmable photonic architecture for quantum information processing” *[Invited]*, U.C. Davis Quantum Journal Club, Davis, CA, January 2020
7. “Universal programmable photonic architecture for quantum information processing”, Stanford Q-FARM Seminar Series, Stanford, CA, November 2019
8. “Universal programmable photonic architecture for quantum information processing” *[Invited]*, Caltech Quantum Machine Learning and Quantum Computation Frameworks (QMLQCF), Pasadena, CA, November 2019
9. “A ‘generative’ model for computing electromagnetic field solutions”, Stanford University Photonics Retreat, Marshall, CA, April 2019
10. “Multi-agent reinforcement learning for unit control in the programming strategy game Screeps”, Stanford MS&E 338 presentations, Stanford, CA, June 2019
11. “A 'generative' model for computing electromagnetic field solutions”, Stanford CS229 presentations, Stanford, CA, December 2018
12. “Hardware-level simulations of nanophotonic neural networks”, Stanford CS230 presentations, Stanford, CA, June 2018
13. “QuTiP lecture: photon scattering in quantum optical systems”, QuTiP Lecture Series, (online at qutip.org), April 2018
14. “A practical framework for simulating quantum networking protocols over noisy information channels”, Intelligent Quantum Networks and Technologies Symposium, Palo Alto, CA, September 2017
15. S. Herrmann, “Electrical manufacturing readiness”, LSST Camera - Corner Raft Manufacturing Readiness Review, July 2016 (presentation featuring my work)
16. M. Spiropulu, “Precision timing in calorimetry”. CPAD Instrumentation Frontier Meeting, Arlington, TX, October 2015 (presentation featuring my work)
17. “Timing simulation studies summary”, Caltech@CMS, Geneva, Switzerland and Pasadena, CA, August 2015
18. “Di-photon vertexing with the High-Granularity Calorimeter”, CMS HGCAL Meeting, Geneva, Switzerland, July 2015
19. “Analysis of a Precambrian resonance-stabilized day length”, American Geophysical Union Fall Meeting, San Francisco, CA, December 2014
20. “Unidirectionalization of particulate distributions in isotropic D+D$\rightarrow{}^{3}$He+n reactions utilizing differential ion velocities”, Intel International Science and Engineering Fair, Pittsburgh, PA, May 2012

Science outreach publications

1. B. Bartlett, "LGBTQ+STEM – Anyone Can Be a Scientist", *Nature Research Device & Materials Engineering Community*, go.nature.com/35zH7Nw (2020)

Open-source software contributions

- `neuroptica`: a flexible simulation package for optical neural networks
  - Repository: github.com/fancompute/neuroptica (★ 141 ⑂ 32)
  - Lead developer (2018 – present): I programmed most of the simulation framework and have been the primary maintainer of the library.
- `SQUANCH`: A distributed simulation framework for quantum networks and channels
  - Repository: github.com/att-innovate/squanch (★ 33 ⑂ 6)
  - Lead developer (2017 – present): I designed the simulation framework, which has been used in multiple publications, and have been responsible for its maintenance.
- `QuTiP`: Quantum Toolbox in Python
  - Repository: github.com/qutip/qutip (★ 1.1k ⑂ 494)
  - Contributor (2018): I wrote the `qutip.scattering` module, which computes scattering in arbitrarily driven quantum systems and was listed as a major feature in the 4.3 release.
- `meep`: open-source electromagnetics simulation package with a broad range of applications
  - Repository: github.com/NanoComp/meep (★ 647 ⑂ 377)
  - Contributor (2021 - 2022): developed the `meep.chunk_balancer` module, providing load-balancing algorithms for massively parallel simulations on shared-resource clusters.

Personal software side projects

- `3D-printed-mirror-array`: Python software which generates custom 3D-printable hexagonal mirror arrays capable of reflecting sunlight into arbitrary patterns
  - Repository: github.com/bencbartlett/3D-printed-mirror-array (★ 2.2k ⑂ 131)
- `Overmind`: a bot written in TypeScript for the programming strategy game Screeps
  - Repository: github.com/bencbartlett/overmind (★ 390 ⑂ 118)
- `ising-compiler`: compiles arbitrary logical circuits into a system of interacting spins, encoding the computation result in the spin ground state when cooled to absolute zero
  - Repository: github.com/fancompute/ising-compiler (★ 46 ⑂ 2)
- `neural-maxwell`: an unsupervised machine learning model for computing approximate electromagnetic field solutions in a cavity containing arbitrary permittivity distributions
  - Repository: github.com/bencbartlett/neural-maxwell (★ 40 ⑂ 15)
- `qpga`: TensorFlow-based simulations of photonic quantum programmable gate arrays
  - Repository: github.com/fancompute/qpga (★ 77 ⑂ 11)
- `Animator5D`: simple library for rendering 5-dimensional (x, y, z, t, color) scatterplot animations with matplotlib

  - Repository: github.com/bencbartlett/Animator5D (★ 81 ⑂ 5)
- `SparkleMotion`: LED control library for displaying music-reactive light shows on BAAAHS (an art car for Burning Man); I have written a lot of the shader art displayed on the car
  - Repository: github.com/baaahs/sparklemotion (★ 27 ⑂ 7)
- `psiblend`: Python library for Blender designed for visualizing quantum photonic circuits and cluster states, developed for work at PsiQuantum
  - Repository (private access): gitlab.psiquantum.com/benbartlett/psiblend

Teaching experience

Primary instructor:

2019 Topics in Physics (Stanford Pre-Collegiate Studies)

Teaching assistant:

2018 Ph113: Computational Physics (Stanford)

2016 CS1: Introduction to Computer Programming (Caltech)

Tutoring:

2014-17 Dean's office tutor for 17 classes at Caltech, including quantum mechanics, computational physics, complexity theory, discrete math, waves, statistical mechanics, relativity, electromagnetism, linear algebra, calculus

Honors and awards

2018 Hertz Fellowship Finalist

2015 Jean J. Dixon Research Fellowship

2014 Caltech Physics 11 Research Fellowship

2013 National Merit Scholar

2012 Davidson Fellows Scholar (honorable mention)

2012 4th place in physics, Intel International Science and Engineering Fair

2012 1st place in physics, US National Junior Science and Humanities Symposium

Selected coursework

- Quantum physics (11 courses)
- Electromagnetism (8 courses)
- Machine learning (5)
- Computational physics (5)
- Experimental physics (5)
- Quantum / modern / nonlinear optics (5)
- Quantum information (3)
- Special and general relativity (3)
- Theory of computation (3)
- History and philosophy of science (3)
- Combinatorics (3)
- Information theory (2)
- Statistical mechanics (2)
- Astrophysics (2)
- Unusual computing systems (2)
- Cryptography (1)

Service

- Reviewer for various scientific journals in physics and optics:
  - Physical Review Letters
  - Physical Review A
  - PRX Quantum
  - Photonics Research
  - Optics Express
  - Communication Physics
  - Optics Letters
  - OSA Continuum
- Server administrator for Hera, the Fan group's computing cluster

Professional memberships

2021-2023 American Physical Society

2020-Present Optical Society of America / Optica

Miscellaneous interests

- Creating Mathematica animations and scientific visualizations
  - Featured contributor, Wolfram Community Staff Picks [link]
- Classical piano
  - Studies at Stanford Music and San Francisco Conservatory of Music [demo]
- GLSL shaders and LED art
- Electronic music production