

Paul D. Nation

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Research Interests

Computational quantum physics, quantum computing, optomechanical systems, superconducting circuit devices, analogue gravitational physics, quantum optics, scientific visualization.

Education

- 2005-2010 **Ph.D. Physics (June 2010)**, *Dartmouth College*, Hanover, New Hampshire USA.
Dissertation Topic: “[Quantum Dynamics of Nonlinear Cavity Systems](#)”
Advisor: Miles P. Blencowe
- 2002-2005 **B.S. Physics**, *Utah State University*, Logan, Utah USA.
Minor: Mathematics
Graduated cum laude: 3.77/4.0

Experience

- 2021-Present **Partners Technical Enablement Director**, *IBM Quantum*, Yorktown Heights USA.
- 2018-Present **Research Staff Member**, *IBM Quantum*, Yorktown Heights USA.
- 2015-2017 **Staff Physicist IV**, *Northrop Grumman Corporation*, Aurora, Colorado USA.
- 2012-2015 **Assistant Professor**, *Korea University Department of Physics*, Seoul, South Korea.
- 2011-2012 **JSPS Foreign Postdoctoral Fellow**, *RIKEN Advanced Science Institute*, Wako-shi, Saitama Japan.
- 2010-2012 **Postdoctoral Research Associate**, *University of Michigan*, Ann-Arbor, Michigan USA.
Department of Physics, based at RIKEN in Japan.
- 2010-2011 **Visiting Researcher**, *RIKEN Advanced Science Institute*, Wako-shi, Saitama Japan.
Member of the Digital Materials Laboratory under Dr. Franco Nori.
- 2005-2010 **Graduate Student**, *Dartmouth College*, Hanover, New Hampshire USA.
Includes Ph.D. research, Ph.D. and Masters level coursework and research projects. Guest lecturer for introductory quantum mechanics in summer 2008.
- 2009 **Visiting Researcher**, *NTT Basic Research Laboratories*, Atsugi, Kanagawa Japan.
Worked with Dr. Hiroshi Yamaguchi, head of the Nanostructure Technology Research Group. Collaboration on using coupled oscillators to realize a purely mechanical ‘single-atom’ laser.
- 2004-2005 **Science Specialist**, *Dugway Proving Grounds*, U.S. Army, Dugway, Utah USA.
Carried out work on modeling biological aerosol clouds and identification of constituent components. Specifically looked at using the fluorescence spectrum of aerosols for use in stand-off detection LIDAR systems.

Publications, * = co-first author

- **P. D. Nation**, Hwajung Kang, Neereja Sundaresan, and Jay M. Gambetta, “Scalable mitigation of measurement errors on quantum computers”, [arXiv:2108.12518](#).
- Antonio D. Córcoles, Abihinav Kandala, Ali Javadi-Abhari, Douglas T. McClure, Andrew W. Cross, Kristan Temme, **Paul D. Nation**, Matthais Steffen, and Jay M. Gambetta, “Challenges and Opportunities of Near-Term Quantum Computing Systems”, [Proc. of IEEE](#) **108**, 1338 (2020).
- Andrew W. Cross, Lev S. Bishop, Sarah Sheldon, **Paul D. Nation**, Jay M. Gambetta, “Validating quantum computers using randomized model circuits”, [Phys. Rev. A](#) **100**, 032328 (2019).

- **P. D. Nation**, J. Suh, and M. P. Blencowe, “Ultrastrong optomechanics incorporating the dynamical Casimir effect”, *Phys. Rev. A* **93**, 022510 (2016).
- **P. D. Nation**, “Steady-state solution methods for open quantum optical systems”, [arXiv:1504.06768](https://arxiv.org/abs/1504.06768).
- **P. D. Nation**, J. R. Johansson, M. P. Blencowe, and A. J. Rimberg, “Iterative solutions to the steady-state density matrix for optomechanical systems”, *Phys. Rev. E* **91**, 013307 (2015).
- A. J. Rimberg, M. P. Blencowe, A. D. Armour, and **P. D. Nation**, “A cavity-Cooper pair transistor scheme for investigating quantum optomechanics in the ultra-strong coupling regime”, *New J. Phys.* **16**, 055008 (2014).
- **P. D. Nation**, “Nonclassical mechanical states in an optomechanical micromaser analog”, *Phys. Rev. A* **88**, 053828 (2013).
- J. R. Johansson, **P. D. Nation***, and F. Nori, “QuTiP 2: A Python framework for the dynamics of open quantum systems”, *Comp. Phys. Comm.* **184**, 1234 (2013).
- **P. D. Nation**, M. P. Blencowe, and F. Nori, “Non-equilibrium Landauer Transport Model for Hawking Radiation from a Black Hole”, *New J. Phys.* **14**, 033013 (2012).
- J. R. Johansson, **P. D. Nation***, and F. Nori, “QuTiP: An open-source Python framework for the dynamics of open quantum systems”, *Comp. Phys. Comm.* **183**, 1760 (2012).
- **P. D. Nation**, J. R. Johansson, M. P. Blencowe, and F. Nori, “Stimulating uncertainty: Amplifying the quantum vacuum with superconducting circuits”, *Rev. Mod. Phys.* **84**, 1 (2012).
- **P. D. Nation** and M. P. Blencowe, “The trilinear Hamiltonian: a zero dimensional model of Hawking radiation from a quantized source”, Invited to focus issue on: “Classical and Quantum Analogues for Gravitational Phenomena and Related Effects”, *New. J. Phys.* **12**, 095013 (2010).
- **P. D. Nation**, M. P. Blencowe, A. J. Rimberg, and E. Buks, “Analogue Hawking Radiation in a dc-SQUID Array Transmission Line”, *Phys. Rev. Lett.* **103**, 087004 (2009).
- **P. D. Nation**, M. P. Blencowe, and E. Buks, “Quantum analysis of a nonlinear microwave-cavity embedded dc-SQUID displacement detector”, *Phys. Rev. B* **78**, 104516 (2008).
- **P. D. Nation**, A. Q. Howard, and L. J. Webb, “Modeling biological fluorescence emission spectra using Lorentz line shapes and nonlinear optimization,” *Appl. Opt.* **46**, 6192 (2007).

Conference Proceedings

- J. R. Johansson and **P. D. Nation**, “QuTiP: A framework for the dynamics of open quantum systems using SciPy and Cython”, *Proc. of the 11th Python in Science Conf.* (2012).

Technical Blogs

- “How to measure and reset a qubit in the middle of a circuit execution”, *IBM Research Blog*, **Paul Nation** and Blake Johnson (February 11, 2021). <https://www.ibm.com/blogs/research/2021/02/quantum-mid-circuit-measurement/>.

Honors and Awards

- 2021 **Outstanding Technical Achievement Award**, IBM Quantum Cloud applications and services (Experience / Lab and API), IBM.
- 2021 **Outstanding Technical Achievement Award**, Define Quantum Volume as a metric, IBM.
- 2020 **Outstanding Research Accomplishment**, IBM Quantum Cloud Applications and Services, IBM.
- 2020 **Outstanding Research Accomplishment**, Quantum Education with Qiskit, IBM.
- 2019 **Outstanding Technical Achievement Award**, Qiskit and IBM Q Experience Ecosystem, IBM.
- 2019 **Corporate Technical Award**, IBM Q 20-qubit system development and deployment, IBM.
- 2014 **Outstanding Teaching Award**, (Computational Physics), Korea University.
- 2012 **Outstanding Teaching Award**, (Introductory Physics), Korea University.

- 2011-2012 **JSPS Foreign Postdoctoral Fellowship**, Japanese Society for the Promotion of Science.
- 2009-2010 **Graduate Assistance in Areas of National Need (GAANN) Fellowship**, U.S. Department of Education.
- 2009 **East Asia and Pacific Summer Institutes Fellowship**, NSF / JSPS.
- 2005-2006 **GAANN Fellowship**, U.S. Department of Education.
- 2005 **Best undergraduate science poster presentation**, Utah State University.

Grants

- 2013-2020 **Brain Korea 21+ (BK21+)** [KRW 2,746,737,000], “Initiative for Creative and Independent Scientists”, Korea University Department of Physics, Multiple Investigators.
- 2011-2012 **JSPS Grants-in-Aid (Kakenhi)** [JPY 1,600,000], “Superconducting Circuits in Space Physics”, Single Investigator: PI Nation.
- 2011-2012 **JSPS** [JPY 8,888,000], “Analogue Cosmology in Superconducting Circuits”, Single Investigator: PI Nation.
- 2009 **NSF [\$5,000]**, “Noise Properties of Nonlinear Quantum Amplifiers Near Bifurcations”, Single Investigator: PI Nation.

Patents

- 2019 **Optimizing Time-Dependent Simulations of Quantum Computing Architectures**, Naoki Kanazawa and **Paul D. Nation**, [US10970234B2](#).
- 2019 **Validating and estimating runtime for quantum algorithms**, Ali Javadi, Ismael Faro, Jay M. Gambetta, and **Paul D. Nation**, [US10790912B2](#).
- 2019 **Visualizing arbitrary pulse shapes and schedules in quantum computing applications**, **Paul D. Nation**, Naoki Kanazawa, and Thomas Arab Alexander, [US20200285986A1](#).
- 2018 **Local Optimization of Quantum Circuits**, **Paul D. Nation**, [US10706365B2](#).
- Filled 2021 **Scalable error mitigation**, **Paul D. Nation**, Hwajung Kang, and Jay M. Gambetta.
- Filled 2020 **Quantum circuit optimization routine evaluation and knowledge base generation**, **Paul D. Nation**, Ali Javadi, Paco Martin, Ismael Faro, and Jay Gambetta.
- Filled 2019 **Quantum adaptive compiler service**, Paco Martin, Ismael Faro, Jay M. Gambetta, and **Paul D. Nation**.
- Filled 2019 **A System and Method for Constructing Numerical Models for Time-Dependent Hamiltonians and Noise Characteristics of Quantum Computing Devices**, Naoki Kanazawa, **Paul D. Nation**, and Thomas Alexander.

Conferences

- 2014 **co-Chair**, [Relativistic Quantum Information - North 2014](#), Seoul, South Korea.

Invited Conference/Workshop Talks

- “Progress Toward Quantum Advantage at IBM”, IEEE, Westminister Colorado, November 2019.
- “Quantum Computing at IBM”, Federated Computing Research Conference, Phoenix Arizona, June 2019.
- “Compiling Quantum Circuits for NISQ Processors”, Korea Institute for Advanced Study, Seoul Korea, Aril 2019.
- “Quantum Computing @ IBM”, International Super Computing (ISC) 2018, Frankfurt Germany, June 2018.
- “Quantum Vacuum Amplification”, 2014 “Open KIAS” School on Quantum Information Science, Seoul Korea, July 2014.

- “Circuit Quantum Electrodynamics: Quantum Optics on a Chip”, 3rd School of Mesoscopic Physics, Buyeo Korea, June 2014.
- “Nonclassical Mechanical States in an Optomechanical Micromaser Analogue”, Nonlinear Dynamics at the Nanoscale, Pohang Korea, August 2013.
- “The Superconducting Circuit Warm Up for Fundamental Physics”, 25th Workshop on Nanoscale and Mesoscopic Systems, Pohang Korea, November 2012.
- “Photon Production from the Quantum Vacuum”, 6th Winter School on Quantum Information Science, Huisun Taiwan, February 2012.
- “Hawking Radiation as a 1D Quantum Channel”, Quantum Science of Strongly Correlated Systems (QS²C) Theory Forum, RIKEN, Wako-shi Japan, September 2010.

Computational Programs

- 2021-Present **Matrix-free Measurement Mitigation (M3)**.
Scalable measurement mitigation on quantum computing platforms.
- 2020-Present **Kaleidoscope**.
Interactive visualizations for quantum computation.
- 2018-Present **Qiskit**, <http://qiskit.org>.
Open-source framework for leveraging noisy quantum computers in research, education, and business. Focus on user-facing functionality, visualizations, and performant numerical methods.
- 2011-2017 **QuTiP: The Quantum Toolbox in Python**, <http://qutip.org>.
Open-source framework for solving the dynamics of open quantum systems. Includes Monte-Carlo and master equation algorithms, supporting arbitrary time-dependent Hamiltonians and Lindbladians. Supports multiprocessing and Cython based just-in-time (JIT) programming for compiled execution of time-dependent Hamiltonians. In collaboration with Dr. Robert J. Johansson.
- 2014-2015 **SciPy**, <http://scipy.org>.
Author of Reverse Cuthill-McKee, Maximum Bipartite Matching, and Structural Rank sparse matrix algorithms in the `scipy.sparse.csgraph` module.

Teaching Experience

- 2012-2015 **Lecturer**, Department of Physics, Korea University.
2014-2015: PHYS-461: Computational Physics.
2013-2014: PHYS-506: Graduate Quantum Mechanics II.
2013-2015: PHYS-505: Graduate Quantum Mechanics.
2013: PHYS-721: Special Topics in Solid State Physics.
2013: PHYS-183: Physics for Life Scientists.
2012-2014: PHYS-152: Introductory Physics II.
- 2009-2010 **Member**, Department of Physics Graduate Committee, Dartmouth College.
First graduate student to be on the graduate committee. Completely rewrote and reinstated the graduate student teaching evaluations that were put on hold in 2006.
- 2006-2009 **Teaching Assistant**, Department of Physics, Dartmouth College.
Small group, hands on laboratory sessions, exam preparation guides, homework / laboratory evaluations, and open-door policy office hours for six undergraduate classes and graduate level quantum mechanics.
- 2008 **Guest Lecturer**, Introductory Quantum Mechanics, Dartmouth College.
Lectures and visual demonstrations for undergraduate introductory quantum mechanics class (Griffith's level).
- 2005 **Teaching Assistant**, Department of Physics, Utah State University.
Conducted laboratory sessions for introductory physics class.

Publicity

- “IBM’s Quantum Computing Compromise—a Road to Scale?”, *IEEE Spectrum*, Edd Gent (August 06, 2021). <https://spectrum.ieee.org/ibm-s-quantum-computing-compromise-the-road-to-scale>.

- Quantum Algorithm Programmed with QuTiP Classifies 9,500 Handwritten Numbers, [IBM Research](#), March 13, 2017.
- QuTiP: Quantum Toolbox in Python mentioned in The Economist Technology Quarterly: “Here, There and Everywhere”, March 9, 2017.
- QuTiP: Quantum Toolbox in Python highlighted in “Programming: Pick up Python”, [Nature](#) **518**, 125 (2015).
- *Rev. Mod. Phys.* Colloquium: “Stimulating uncertainty: Amplifying the quantum vacuum with superconducting circuits” highlighted in *APS News*, Vol. 21, No. 2 (February 2012). <http://www.aps.org/publications/apsnews/201202/index.cfm>.
- “Quantum string links black holes and violins”, *Medill Reports*, Justin Eure (March 09, 2011). <http://news.medill.northwestern.edu/chicago/news.aspx?id=182459>.
- “Building Black Holes”, *Forbes*, Jonathan Fahey (October 27, 2009). <http://www.forbes.com/2009/10/27/physics-metamaterials-gravity-technology-breakthroughs-black-holes.html>.
- “Simulated Black Holes May Prove Hawking’s Theory”, *Discovery News*, Eric Bland (September 10, 2009). <http://news.discovery.com/tech/black-hole-simulation.html>.
- “An event on the horizon”, *Physics*, Jessica Thomas (August 17, 2009). <http://physics.aps.org/synopsis-for/10.1103/PhysRevLett.103.087004>.
- “Scientists Propose Lab-Grade Black Holes”, *ScienceNews*, Laura Sanders (August 13, 2009). http://www.sciencenews.org/view/generic/id/46371/title/Scientists_propose_lab-grade_black_holes.

Public Outreach

- “Current Topics in Science: From Bananas to Zombies”, Montessori School Tokyo, Tokyo Japan, January 2012.
- Judge for Science Fair International 2011, Columbia International School, Tokorozawa Japan, November 2011.
- “Why Choose a Career in Science?”, Utsunomiya Girls High School, Utsunomiya Japan, September 2011.

Journal Referee

- GRG, IEEE Transactions on Quantum Engineering, Nat. Commun., Nat. Phys., Nat. Rev. Phys., NJP, PRA, PRB, PRE, PRL, PRX, RMP.