

Patrick J. Coles

Scientist 3, Theoretical Division, Los Alamos National Laboratory
Phone: 505-667-5656 E-Mail: pcoles@lanl.gov Citizenship: United States

Research Directions

Quantum computing, quantum machine learning, quantum cryptography, quantum information theory, quantum optics, quantum foundations.

Academic Positions and Education

Los Alamos National Laboratory 2017 – Present

Staff Scientist, Level 3, Theoretical Division

University of Waterloo 2014 – 2017

Institute for Quantum Computing, Department of Physics
Postdoctoral Researcher

National University of Singapore 2012 – 2014

Centre for Quantum Technologies
Postdoctoral Researcher

Carnegie Mellon University 2008 – 2012

Department of Physics
Postdoctoral Researcher

University of California, Berkeley 2002 – 2008

Department of Chemical Engineering
Ph.D., *NSF Fellow*

University of Cambridge 2001 – 2002

Department of Biochemistry
M.Phil., *Churchill Fellow*
(only 11 Churchill Scholarships awarded annually)

Case Western Reserve University 1997 – 2001

B.S., Chemical Engineering
GPA: 4.0 (maximum possible GPA: 4.0)

Grant Awards

Proposal: “Machine Learning of Quantum Computing Algorithms”

Early Career Research Award (Individual Grant)

Awarded by: LANL Laboratory Directed Research and Development

Funding Period: Oct. 1, 2018 – Sep. 30, 2020

Proposal: “Taming Defects in Quantum Computers”

Directed Research Award (Grant for team of 9 LANL Scientists)

Awarded by: LANL Laboratory Directed Research and Development

Funding Period: Oct. 1, 2018 – Sep. 30, 2021

Proposal: “Optimization, Verification, and Engineered Reliability of Quantum Computers”

Quantum Computing Applications Team (QCAT) Award

(Grant for team of 12 Scientists from Sandia, LANL, and Dartmouth)

Awarded by: Advanced Scientific Computing Research (ASCR), DOE

Funding Period: Oct. 1, 2018 – Sep. 30, 2022

Proposal: “Topological phases of quantum matter and decoherence”

(Grant for team of 6 Scientists from LANL)

Awarded by: Basic Energy Sciences (BES), DOE

Funding Period: Oct. 1, 2018 – Sep. 30, 2021

Proposal: “Disentangling quantum entanglement”

(Grant for team of 5 Scientists from LANL and UC Davis)

Awarded by: High Energy Physics (HEP), DOE

Funding Period: Oct. 1, 2018 – Sep. 30, 2020

Proposal: “Quantum Principal Component Analysis on IBM’s Quantum Computer”

Quantum Computing Education, Rapid Response (Individual Grant)

Awarded by: LANL Information Science and Technology Institute

Funding Period: Sep. 2017 – Dec. 2017

School Organizer: LANL Quantum Computing Summer School

Lead organizer. Responsible for inviting speakers, organizing lectures, mentoring students.

School Format: Ten students. Two weeks of lectures followed by eight weeks of research.

Students given access to and trained on commercial quantum computers from D-Wave, IBM, Rigetti.

School website: <http://quantumcomputing.lanl.gov>

Software Development

University of Waterloo

Led a team of students in developing the first software for calculating key rates of quantum key distribution (QKD) protocols. The software is a GUI based in Matlab. It is publicly available at this website:

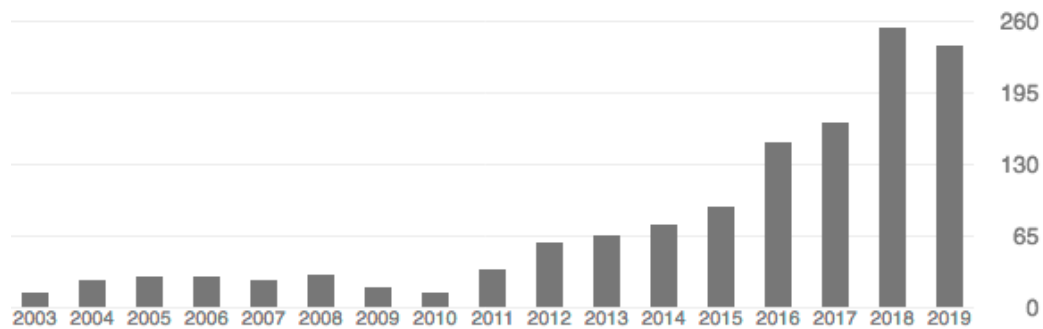
<https://lutkenhausgroup.wordpress.com/qkd-software/>

Publications

Citations

Total: 1351, h-index: 19

(from Google Scholar, accessed on Aug. 8, 2019)



Review article

38. **P. J. Coles**, M. Berta, M. Tomamichel, S. Wehner
Entropic uncertainty relations and their applications
Reviews of Modern Physics. 89: 015002. (2017).
<https://journals.aps.org/rmp/abstract/10.1103/RevModPhys.89.015002>

Peer-reviewed articles

37. **P. J. Coles**, M. Cerezo, L. Cincio
Strong bound between trace distance and Hilbert-Schmidt distance for low-rank states
Physical Review A. 100, 022103 (2019)
<https://journals.aps.org/pr/abstract/10.1103/PhysRevA.100.022103>
36. A. Arrasmith, L. Cincio, A. Sornborger, W. Zurek, **P. J. Coles**
Variational consistent histories as a hybrid algorithm for quantum foundations
Nature Communications. 10 (1), 3438 (2019)
<https://www.nature.com/articles/s41467-019-11417-0>
35. R. LaRose, A. Tikku, E. O'Neel-Judy, L. Cincio, **P. J. Coles**
Variational quantum state diagonalization
npj Quantum Information. 5 (1), 8 (2019)
<https://www.nature.com/articles/s41534-019-0167-6>
34. S. Khatra, R. LaRose, A. Poremba, L. Cincio, A. T. Sornborger, **P. J. Coles**
Quantum-assisted quantum compiling
Quantum. 3, 140 (2019)
<https://quantum-journal.org/papers/q-2019-05-13-140/>

33. **P. J. Coles**, V. Katariya, S. Lloyd, I. Marvian, M. M. Wilde
 Entropic energy-time uncertainty relation
Physical Review Letters. 122 (10), 100401 (2019)
<https://journals.aps.org/prl/abstract/10.1103/PhysRevLett.122.100401>

32. Y. Subasi, L. Cincio, **P. J. Coles**
 Entanglement spectroscopy with a depth-two quantum circuit
Journal of Physics A: Mathematical and Theoretical. 52: 044001 (2019)
<https://iopscience.iop.org/article/10.1088/1751-8121/aaf54d>

31. L. Cincio, Y. Subasi, A. T. Sornborger, **P. J. Coles**
 Learning the quantum algorithm for state overlap
New Journal of Physics. 20 (11), 113022 (2018)
<https://arxiv.org/abs/1803.04114>

30. A. Winick, N. Lutkenhaus, **P. J. Coles**
 Reliable numerical key rates for quantum key distribution
Quantum. 2: 77. (2018)
<https://quantum-journal.org/papers/q-2018-07-26-77/>

29. F. Rozpedek, J. Kaniewski, **P. J. Coles**, S. Wehner
 Quantum preparation uncertainty and lack of information
New Journal of Physics. 19: 023038. (2017)
<http://iopscience.iop.org/article/10.1088/1367-2630/aa5d64/meta;jsessionid=720C9852D43866FED1E2F373404D076F.ip-10-40-2-120>

28. **P. J. Coles**, E. M. Metodiev, N. Lütkenhaus
 Numerical approach for unstructured quantum key distribution
Nature Communications. 7: 11712. (2016)
<http://www.nature.com/ncomms/2016/160520/ncomms11712/full/ncomms11712.html>

27. **P. J. Coles**
 Entropic framework for wave-particle duality in multi-path interferometers
Physical Review A. 93: 062111. (2016)
<http://journals.aps.org/pra/abstract/10.1103/PhysRevA.93.062111>

26. C. Pfister, N. Lütkenhaus, S. Wehner, **P. J. Coles**
 Sifting attacks in finite-size quantum key distribution
New Journal of Physics. 18: 053001. (2016)
<http://iopscience.iop.org/article/10.1088/1367-2630/18/5/053001/meta>

25. D. B. S. Soh, C. Brif, **P. J. Coles**, N. Lütkenhaus, R. M. Camacho, J. Urayama, M. Sarovar
 Self-referenced continuous-variable quantum key distribution protocol
Physical Review X. 5: 041010. (2015)
<https://journals.aps.org/prx/abstract/10.1103/PhysRevX.5.041010>

24. **P. J. Coles** and F. Furrer
State-dependent approach to entropic measurement-disturbance relations
Physics Letters A. 379: 105-112. (2015)
<http://www.sciencedirect.com/science/article/pii/S0375960114011098>
23. **P. J. Coles**, J. Kaniewski, S. Wehner
Equivalence of wave-particle duality to entropic uncertainty
Nature Communications. 5: 5814. (2014)
<http://www.nature.com/doi/10.1038/ncomms6814>
22. M. Berta, **P. J. Coles**, S. Wehner
Entanglement-assisted guessing of complementary measurement outcomes
Physical Review A. 90: 062127. (2014)
<http://link.aps.org/doi/10.1103/PhysRevA.90.062127>
21. **P. J. Coles** and M. Piani
Complementary sequential measurements generate entanglement
Physical Review A: Rapid Communications. 89: 010302(R). (2014) **Selected for Editors' Suggestion**
<http://link.aps.org/doi/10.1103/PhysRevA.89.010302>
20. **P. J. Coles** and M. Piani
Improved entropic uncertainty relations and information exclusion relations
Physical Review A. 89: 022112. (2014)
<http://link.aps.org/doi/10.1103/PhysRevA.89.022112>
19. **P. J. Coles**
Role of complementarity in superdense coding
Physical Review A. 88: 062317. (2013)
<http://link.aps.org/doi/10.1103/PhysRevA.88.062317>
18. **P. J. Coles**
Collapse of the quantum correlation hierarchy links entropic uncertainty to entanglement creation
Physical Review A. 86: 062334. (2012)
<http://link.aps.org/doi/10.1103/PhysRevA.86.062334>
17. **P. J. Coles**, V. Gheorghiu, R. Griffiths
Collisional decoherence of tunneling molecules: a consistent histories treatment
Physical Review A. 86: 042111. (2012)
<http://link.aps.org/doi/10.1103/PhysRevA.86.042111>
16. **P. J. Coles**, R. Colbeck, L. Yu, M. Zwolak
Uncertainty relations from simple entropic properties
Physical Review Letters. 108: 210405. (2012)
<http://link.aps.org/doi/10.1103/PhysRevLett.108.210405>

15. **P. J. Coles**
Unification of different views of decoherence and discord
Physical Review A. 85: 042103. (2012)
<http://link.aps.org/doi/10.1103/PhysRevA.85.042103>
14. **P. J. Coles**, L. Yu, V. Gheorghiu, R. Griffiths
Information-theoretic treatment of tripartite systems and quantum channels
Physical Review A. 83: 062338. (2011)
<http://link.aps.org/doi/10.1103/PhysRevA.83.062338>
13. J. King, **P. J. Coles**, J. Reimer
Optical polarization of ^{13}C nuclei in diamond through nitrogen vacancy centers
Physical Review B. 81: 073201. (2010)
<http://link.aps.org/doi/10.1103/PhysRevB.81.073201>
12. B. Li, **P. J. Coles**, J. Reimer, P. Dawson, C. Meriles
Optical pumping of nuclear spin magnetization in GaAs/AlAs quantum wells of variable electron density
Solid State Communications. 150: 450-453. (2010)
<http://www.sciencedirect.com/science/article/pii/S0038109809007558>
11. **P. J. Coles**
Helicity asymmetry of optically pumped NMR spectra in GaAs
Physical Review B. 78: 033201. (2008)
<http://journals.aps.org/prb/abstract/10.1103/PhysRevB.78.033201>
10. **P. J. Coles** and J. Reimer
Penetration depth model for optical alignment of nuclear spins in GaAs.
Physical Review B. 76: 174440. (2007)
<http://journals.aps.org/prb/abstract/10.1103/PhysRevB.76.174440>
9. A. Paravastu, **P. J. Coles**, J. Reimer, T. Ladd, R. Maxwell
Photocurrent-modulated optical nuclear polarization in bulk GaAs
Applied Physics Letters, 87: 232109. (2005)
<http://scitation.aip.org/content/aip/journal/apl/87/23/10.1063/1.2140484>
8. T. Ali, **P. J. Coles**, T. Stevens, K. Stott, J. Thomas
Two homologous domains of similar structure but different stability in the yeast linker histone, Hho1P
Journal of Molecular Biology, 338:139. (2004)
<http://www.sciencedirect.com/science/article/pii/S0022283604002232>

7. M. Thibonnier, **P. J. Coles**, A. Thibonnier, and M. Shoham
Molecular Pharmacology and Modeling of Vasopressin Receptors
Progress in Brain Research, 139:179-96. (2002)
<http://www.sciencedirect.com/science/article/pii/S0079612302390162>
6. M. Thibonnier, **P. J. Coles**, A. Thibonnier, and M. Shoham
The Basic and Clinical Pharmacology of Nonpeptide Vasopressin Receptor Antagonists
Annual Review of Pharmacology and Toxicology, 41:175-202. (2001)
<http://www.annualreviews.org/doi/abs/10.1146/annurev.pharmtox.41.1.175>
5. M. Thibonnier, **P. J. Coles**, D. Conarty, C. Plesnicher, and M. Shoham
Molecular model of agonist and nonpeptide antagonist binding to the human V₁ vascular vasopressin receptor
Journal of Pharmacology and Experimental Therapeutics, 294:195-203. (2000)
<http://jpet.aspetjournals.org/content/294/1/195.short>

Preprints

4. M. Cerezo, A. Poremba, L. Cincio, **P. J. Coles**
Variational quantum fidelity estimation
arXiv:1906.09253. (2019)
<https://arxiv.org/abs/1906.09253>
3. **P. J. Coles**, et al. (31 co-authors)
Quantum algorithm implementations for beginners
arXiv:1804.03719. (2018)
<https://arxiv.org/abs/1804.03719>
2. **P. J. Coles**, L. Yu, M. Zwolak
Relative entropy derivation of the uncertainty principle with quantum side information
arXiv:1105.4865. (2011)
<http://arxiv.org/abs/1105.4865>
1. **P. J. Coles**
Non-negative discord strengthens the subadditivity of quantum entropy functions
arXiv:1101.1717. (2011)
<http://arxiv.org/abs/1101.1717>

Media Coverage

Quantum key distribution

- Science Daily
<https://www.sciencedaily.com/releases/2016/05/160523104817.htm>
- Phys.org
<http://phys.org/news/2016-05-secret-unbreakable-key.html>
- Scientific Computing
<http://www.scientificcomputing.com/news/2016/05/computing-secret-unbreakable-key>
- ECN
<http://www.ecnmag.com/news/2016/05/computing-secret-unbreakable-key>
- EurekAlert!
http://www.eurekalert.org/pub_releases/2016-05/uow-cas052016.php
- University of Waterloo
<https://uwaterloo.ca/news/news/computing-secret-unbreakable-key>

Wave-particle duality

- Huffington Post
http://www.huffingtonpost.com/2014/12/24/quantum-physics-easier-to-understand_n_6370570.html
- Ten of the biggest science and technology stories of 2014 (phys.org)
<http://phys.org/news/2014-12-ten-biggest-science-technology-stories.html>
- Asian Scientist
<http://www.asianscientist.com/2014/12/in-the-lab/bridging-mysteries-heart-quantum-physics/>
- University of Waterloo
<https://uwaterloo.ca/stories/quantum-physics-breakthrough-scientists-solve-100-year-old>
- Motherboard Vice
http://motherboard.vice.com/en_us/read/how-digital-information-unifies-quantum-mechanics
- Phys.org
<http://phys.org/news/2014-12-quantum-physics-complicated.html>
- From Quarks to Quasars
<http://www.fromquarkstoquasars.com/particle-wave-duality-quantum-uncertainty-principle-united/>
- EurekAlert! http://www.eurekalert.org/pub_releases/2014-12/cfat-qpj121814.php
- International Business Times
<http://www.ibtimes.co.uk/quantum-physics-just-got-less-complicated-rosetta-stone-breakthrough-1480238>
- Controlled Environments
<http://www.cemag.us/news/2014/12/making-quantum-physics-less-complicated>
- Opli http://www.opli.net/opli_magazine/eo/2014/quantum-physics-just-got-less-complicated-dec-news/
- Science Daily <http://www.sciencedaily.com/releases/2014/12/141219085153.htm>
- Nanowerk <http://www.nanowerk.com/nanotechnology-news/newsid=38529.php>
- (e) Science News
<http://esciencenews.com/articles/2014/12/19/quantum.physics.just.got.less.complicated>
- R&D Magazine <http://www.rdmag.com/news/2014/12/quantum-physics-just-got-less-complicated>
- Laboratory Equipment <http://www.laboratoryequipment.com/news/2014/12/good-news-quantum-physics-just-got-less-complicated>

Visiting Research Invitations

Sandia National Laboratory Continuous-variable quantum key distribution <i>Host: Mohan Sarovar, Researcher</i>	Feb. 2015
ETH Zurich Quantum information resource theories <i>Host: Joe Renes, Researcher</i>	Oct. 2013
University of Waterloo Entanglement and the uncertainty principle <i>Host: Marco Piani, Assistant Professor</i>	Jun. 2012
Perimeter Institute for Theoretical Physics General framework for proving uncertainty relations <i>Host: Roger Colbeck, Assistant Professor</i>	Jun. 2011
Los Alamos National Laboratory Correlations in quantum systems <i>Host: Michael Zwolak, Assistant Professor</i>	Feb. 2011

Invited Faculty Position

University of New Mexico
Center for Quantum Information and Control (CQuIC)
Adjunct Assistant Professor (January 2019 – Present)

Invited Talks

Physics Department Colloquium, Louisiana State University Baton Rouge, USA “Hybrid quantum-classical algorithms”	Apr. 2019
Quantum Computing and Information for Nuclear Physics Santa Fe, USA “Machine Learning for Quantum Computing”	Jan. 2019
CQuIC Seminar, University of New Mexico Albuquerque, USA	Jan. 2018

“Automation in quantum information”

SPIE Conference on Quantum Communication **Aug. 2016**

San Diego, USA

“Unstructured quantum key distribution”

Workshop on Beyond I.I.D. in Information Theory **July 2016**

Barcelona, Spain

“Entropic uncertainty relations and their applications”

Quantum Foundations Seminar **Nov. 2014**

Perimeter Institute for Theoretical Physics, Canada

“Equivalence of wave-particle duality to entropic uncertainty”

Quantum Lunch Seminar **Feb. 2011**

Los Alamos National Lab, USA

“Diagrammatic approach to Consistent Histories”

Quantum Lunch Seminar **Nov. 2010**

Los Alamos National Lab, USA

“Information-theoretic treatment of tripartite systems and quantum channels”

Quantum Coherence and Decoherence Workshop **Sep. 2010**

Benasque, Spain

“Information-theoretic treatment of tripartite systems and quantum channels”

UC Berkeley, Dept. of Chemical Engineering Colloquium **Apr. 2007**

Berkeley, USA

“Laser-Induced Nuclear Spin Alignment in GaAs”

Honors

Research Awards

- Best-poster-award in the physics category of LANL's 2018 summer student symposium
- Best-poster-award at the largest international conference on quantum cryptography (QCRYPT) in 2012

Miscellaneous Awards

- LANL Certificate of Recognition for organizing the quantum computing summer school
- Outstanding Reviewer for the journal *Physics Letters A*, awarded in 2015

Graduate Fellowships

- Churchill Fellowship
(11 awarded nationwide annually, for US students to pursue a Masters Degree at Cambridge)
- National Science Foundation Graduate Fellowship

- NDSEG Fellowship from the Department of Defense (Declined due to NSF Fellowship)
- University of California, Berkeley Fellowship (Declined due to Churchill Fellowship)

Undergraduate Scholarships

- Society for Analytical Chemists of Pittsburgh (SACP) \$16,000 College Scholarship (\$16,000 scholarship awarded based on my score on annual ACS high-school chemistry exam.)
- Case Western Alumni Scholarship
- Case Western Presidential Scholarship
- Zeta Beta Tau Fraternity 4.0 Scholarship

Undergraduate Awards

- AIChE (American Institute of Chemical Engineers) Research Award
- Bahnsen Award: achievement in Chemical Engineering and outstanding research projects
- Case Alumni Prize: senior with best academic record in the Case School of Engineering
- Outstanding Junior Award of the Case School of Engineering
- Outstanding Sophomore Award of the Case School of Engineering
- Kilpatrick Award: senior varsity athlete with highest GPA
- UAA All-Academic (1998 – 2001)
- NSCAA/Adidas Scholar Athlete - Honorable Mention (1999)
- Tau Beta Pi Honor Society (HS), Mortar Board HS, Gamma Sigma Alpha HS, Golden Key HS

Teaching Experience

Los Alamos National Laboratory

- Lecturer and mentor for LANL Quantum Computing Summer School. Mentored 8 summer students on quantum computing research projects.

University of Waterloo

- Lecturer on quantum information theory: Developed and taught a special topics course on quantum information theory, offered to graduate students in June 2016.
- Lecturer at the Undergraduate School for Experimental Quantum Information Processing (USEQIP), from 2015 to present.
- Mentored three undergraduate students and two graduate students on quantum optics and quantum information research projects.

National University of Singapore

- Mentored graduate and undergraduate students on quantum information research projects.

Carnegie Mellon University

- Lecturer on Quantum Optics: Developed and taught a graduate course, the first quantum optics course ever offered at Carnegie Mellon. Topics covered included field quantization, field states, characteristic functions, field-atom interaction, spontaneous emission, open systems, quantum jumps, lasers, experimental paradigms, Casimir's effect, optical devices (beam splitters, interferometers, detectors), quantum information, and optical tests of quantum foundations.

University of California, Berkeley

- Graduate Student Instructor: Chemical Engineering 162 - Process Dynamics and Control.
- Graduate Student Instructor: Chemical Engineering 137 - Transport Laboratory

Case Western Reserve University

- Supplemental Instructor: Organic Chemistry I and II.

Additional Experience

Machine Learning and Neural Networks

- Certification in Machine Learning course offered by Coursera, Stanford University (Dec. 2016).
- Certification in Neural Networks course offered by Coursera, University of Toronto (March 2017).

Conference Organizer

- Organizing committee member for the largest international conference on quantum cryptography (QCRYPT), hosted by National University of Singapore in 2012.

Hiring Committee

- Member of LANL hiring committee for new staff scientist in quantum computing, CCS-3 group.

Referee

- Referee for Physical Review Letters, IEEE Transactions on Information Theory, Physical Review A, New Journal of Physics, International Journal of Quantum Information, Quantum Information Processing, Scientific Reports, Physical Letters A, and Journal of Physics A.

REFERENCES

Robert Griffiths

Otto Stern University Professor of Physics
Department of Physics
Carnegie Mellon University
Phone: 4122682765
Email: rgrif@andrew.cmu.edu
Relationship: Postdoc advisor

Norbert Lutkenhaus

Professor
Institute for Quantum Computing
Department of Physics
University of Waterloo
Phone: 5198884567 ext. 32870
Email: lutkenhaus.office@uwaterloo.ca
Relationship: Postdoc advisor

Stephanie Wehner

Associate Professor
QuTech
Delft University of Technology
Phone: +31 152787746
Email: s.d.c.wehner@tudelft.nl
Relationship: Postdoc advisor