

Graeme Smith

JILA
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Employment

Associate Professor of Physics, University of Colorado, Boulder, 2021—
Assistant Professor of Physics, University of Colorado, Boulder, 2016–2021
Associate Fellow, JILA (2016–2020), Fellow, JILA (2020–)
Director, Center for the Theory of Quantum Matter, University of Colorado, Boulder, 2021—
Research Staff Member, Physical Sciences, IBM TJ Watson Research Center, 2010–2016
Postdoc, Physical Sciences, IBM TJ Watson Research Center, 2007–2010
Research Associate, Department of Computer Science, University of Bristol 2006–2007

Education

Ph.D. Physics, California Institute of Technology, 2006
Thesis Title: Upper and Lower Bounds on Quantum Codes, Advisor: John Preskill
M.S. Physics, California Institute of Technology, 2004
B.Sc. Honours Physics with highest Honours, University of Toronto, 2001

Research Interests

Computation and communication in noisy settings
Quantum Networks
Quantum Shannon Theory
Coding theory and Fault Tolerance
Dynamics of Entanglement
Quantum Information in High Energy Physics
Cryptography
Quantum Device Characterization
Estimation, detection, sensing
Physics of Information

Funding History

DOE HEP Consortium. Complex Quantum Systems and The Quantum Universe. (PI: Vijay Balasubramanian, co-PI: Graeme Smith and others). 2021-2024. \$160,000/yr.

DOE Center. Quantum System Accelerator. Prime Contractor: Lawrence Berkeley National Lab. 2021-2026 \$ 200,000/yr.

ARO MURI. Robust Entanglement Distribution in Quantum Networks— Network Science and Architectures for Novel Quantum Information Processing. (PI: Chee Wei Wong, UCLA; co-PI: Graeme Smith and others). 2021-2024. \$175,000/yr.

DARPA ONISQ. *QAOA for Max-Cut on a 2D Neutral Atom Processor*. Prime contractor: Cold Quanta. Subcontract to CU \approx \$ 100, 000/yr.

DOE QuantISED *Measures of Holographic Correlation: Discovery, Interpretation, Application*. (PI: Graeme Smith, co-PI: Oliver DeWolfe) 2019-2021 \$ 350,000

DOE QIS for FES *Plasma Theory Connections to Quantum Information Science* (PI: Scott Parker, co-PI: Graeme Smith) 2019-2022 \$680,212 total. My portion: \approx \$22,000 per year.

NSF QIS *Multiparty Quantum Correlations: Classification and Physical Interpretation*. 2019-2022, \$465,000.

NSF CCF grant for Rocky Mountain Summit on Quantum Information, held here in June. (PI: Felix Leditzky, co-PI: Graeme Smith) \$10k travel support for US students.

NSF Career Award 2017-2022. *Quantifying Noisy Quantum Resources*. \$ 550,000.

Investigator on JILA PFC 2017-2022. \approx \$ 95,000/yr.

Awards

Oustanding Postdoctoral Mentor Award, CU Boulder (2021)

NSF Career Award (2017)

Kavli Fellow (2014)

IBM Research Technical Accomplishment Award (2009)

2008 Pat Goldberg Memorial Best Paper Award in CS, EE, and Math (IBM Research)

First Prize, Canadian Association of Physicists Undergraduate exam (2000)

Publications summary

3576 citations and h index of 31 as of 11/24/2021. Data from google scholar.

55 peer reviewed journal publications including articles in Nature (2), Science Magazine, Nature Physics, Nature Photonics (2), Nature Communications, Physical Review Letters (18), IEEE Transactions on Information Theory (11), Physical Review A, Physical Review B, Physical Review D, Physical Review X.

Selected Publications

Playing games with multiple access channels. Felix Leditzky, Mohammad Alhejji, Joshua Levin, **Graeme Smith** Nature communications 11 (1), 1-5 (2020)

Quantum and private capacities of low-noise channels. Felix Leditzky, Debbie Leung, **Graeme Smith**. Phys. Rev. Lett. 120, 160503 (2018)

Uniform Additivity in Classical and Quantum Information. Andrew W. Cross, Ke Li, **Graeme Smith**. Phys. Rev. Lett. 118, 040501 (2017)

Trading classical and quantum computational resources. Sergey Bravyi, **Graeme Smith** and John Smolin. Phys. Rev. X 6 (2), 021043 (2016)

An exactly solvable model of quantum communications . **Graeme Smith** and John Smolin. Nature 504, 263–267 (2013)

Putting “Quantumness” to the Test. **Graeme Smith** and John Smolin. Physics 6, 105 (2013)

Oversimplifying quantum factoring. John Smolin, **Graeme Smith** and Alexander Vargo. Nature 499, 163-165 (2013)

Limits on classical communication from quantum entropy power inequalities . Robert Koenig and **Graeme Smith**. Nature Photonics 7, 142-146 (2013)

Quantum communication with Gaussian channels of zero quantum capacity. **Graeme Smith**, John Smolin, Jon Yard. Nature Photonics 5, 624-627 (2011)

Quantum communication with zero-capacity channels. **Graeme Smith**, Jon Yard. Science 321, 1812-1815 (2008)

Selected Talks

“Creating an Introductory-Level Interdisciplinary Course in Quantum Information”, Invited Talk at American Physical Society March Meeting 2021.

“The theory of quantum information: channels, capacities, and all that”, Perimeter Institute Quantum Information Seminar, 2021.

“ Multipartite Optimized Correlation Measures”, Berkeley String Theory/HEP-QIS Seminar, 2020.

“Quantum Computing and Quantum Information”, Los Alamos National Lab Quantum Computing Summer School, 2020.

“Playing Games with Multiple Access Channels”, Invited talk at 57th Annual Allerton Conference on Communication, Control, and Computing, 2019.

“Monotonicity Under Local Operations: Linear Entropic Formulas”, 2nd IAMCS Workshop on Quantum Computation and Information, 2019

“Progress on the quantum channel capacity problems”, 20th Annual SQuInT Workshop, 2018

“Uniformly Additive Entropic Formulas ”, QMATH13, 2016

“Quantum Information theory: From kooky to respectable in 50 years”, Invited Talk, DAMOP 2015

“Theoretical Quantum Communications”, Chinese-American Kavli Frontiers of Science Symposium 2014

“Limits on classical communication from quantum entropy power inequalities”, Invited talk at American Physical Society March Meeting 2013

“Quantum Channels and their Capacities”, 11th Canadian Summer School on Quantum Information, 2011

“Quantum Channel Capacities”, Invited talk at IEEE Information Theory Workshop 2010

“Regularization and its Discontents”, Plenary tutorial talk at QIP 2010

“Surprises in the Theory of Quantum Communication”, Invited talk at American Physical Society March Meeting 2010

“Quantum Communication with Zero-Capacity Channels”, Plenary talk at QIP 2009

Contributed talks at QIP 2006, 2007, 2008, 2013. Coauthor of further talks in 2007, 2009, 2012 and 2014, 2016, 2019.

Teaching and Mentoring

Courses Taught

PHYS 2170, Introduction to Modern Physics

PHYS 4230 Thermodynamics and Statistical Mechanics

PHYS 3090, Introduction to Quantum Computing

PHYS 5030 Intermediate Mathematical Physics I

PHYS 7810/7570 Quantum Information and Computing

Courses Created

PHYS/CSCI 3090, Introduction to Quantum Computing (undergraduate class)

PHYS 7570 Quantum Information and Computing (advanced graduate class)

Undergraduate Students Advised

Aaron Barbosa, UT Dallas junior and REU student. 2019

Graduate Students Advised

Mohammad Alhejji, 2017-present

Sristy Agrawal, 2019-present

Jacob Beckey, 2019-present

Josh Levin, 2017-present

Guangkuo Liu, 2020-present

Charles Marrder, 2020-present

Anthony Polloreno, 2019-present

Akshay Seshadri (co-advisor) 2020-present

Ariel Shlosberg, 2018-present

Postdoctoral Associates Advised

Vikesh Siddhu, 2021-present

Felix Leditzky, 2016-2019 (now Assistant Professor of Mathematics, UIUC)

Ke Li, 2013-2016 (now Full Professor of Mathematics at Harbin Institute of Technology)

Maris Ozols, 2012-2013 (now Researcher at QuSoft and Assistant Professor at University of Amsterdam)

Professional Service

Organizer, Physics and Information Capabilities of Highly Entangled Quantum Matter, Aspen Center for Physics, 2022

Associate Editor, IEEE Transactions on Information Theory, 2021–

Local Organizer, QIP 2019

Steering committee QIP 2017-2019 (chair 2018-2019)

co-organizer, Rocky Mountain Summit on Quantum Information, 2018

co-organizer, Boulder School for Condensed Matter and Materials Physics, 2018

Editor, Quantum Information, Annals of Physics 2017–2021

Organizing Committee for “What do we do with a small quantum computer?” workshop, December 2013 at IBM Research

Program Committee for QIP 2011, 2012, 2014, 2017, 2021

Program Committee for Asian Quantum Information Sciences Conference 2012, 2013, 2017

Program Committee for Post-Quantum Cryptography 2010

NSF Panelist 2014, 2016, 2018, 2020

Further Talks

Invited conference talks at APS March Meeting, Allerton, DAMOP, QCRYPT, GPOTS, and SQUINT. Seminars and colloquia at Bell Labs, Bristol, Caltech, Calgary, CWI, Copenhagen, Gdansk, Guelph, IBM, KITP/UCSB, Los Alamos, LSU, MIT, Maryland, McGill, Microsoft, Mittag-Leffler, NASA/JPL, Northeastern, Perimeter Institute, Queensland, Tsinghua, UCLA, Waterloo and Wisconsin.

Publications

Preprints

67. *Towards Demonstrating Fault Tolerance in Small Circuits Using Bacon-Shor Codes* A Shlosberg, AM Polloreno, G Smith. arXiv preprint arXiv:2108.02079
66. *Entropy transfer from a quantum particle to a classical coherent light field.* JP Bartolotta, SB Jäger, JT Reilly, MA Norcia, JK Thompson, G Smith, MJ Holland. arXiv preprint arXiv:2105.03780
65. *Better transmission with lower capacity: lossy compression over quantum channels* S Agrawal, R Tarafder, G Smith, A Roy, M Banik. arXiv preprint arXiv:2105.06617
64. *Quantifying coherence and entanglement via simple measurements.* G Smith, JA Smolin, X Yuan, Q Zhao, D Girolami, X Ma. arXiv:1707.09928
63. *Comment on "Distinguishing Classical and Quantum Models for the D-Wave Device".* Seung Woo Shin, **Graeme Smith**, John A. Smolin, Umesh Vazirani. arXiv:1404.6499
62. *How "Quantum" is the D-Wave Machine?.* Seung Woo Shin, **Graeme Smith**, John A. Smolin, Umesh Vazirani. arXiv:1401.7087.

Refereed Conference Proceedings

61. *A Tight Uniform Continuity Bound for Equivocation.* Mohammad A. Alhejji and **Graeme Smith**, IEEE International Symposium on Information Theory, 2270-2274 (2020)
60. *Hybrid Quantum-Classical Computing Architectures.* Martin Suchara, Yuri Alexeev, Frederic Chong, Hal Finkel, Henry Hoffmann, Jeffrey Larson, James Osborn, and **Graeme Smith**. In Proceedings of the 3rd International Workshop on Post-Moore Era Supercomputing, 2018.
59. *Degradable states and one-way entanglement distillation,* Felix Leditzky, Nilanjana Datta and Graeme Smith. Proceedings of IEEE International Symposium on Information Theory, 1559-1562 (2017)
58. *New constructions of codes for asymmetric channels via concatenation,* Markus Grassl, Peter Shor, **Graeme Smith**, John Smolin and Bei Zeng. Proceedings of IEEE International Symposium on Information Theory, 751-755 (2012)
57. *Quantum Channel Capacities.* **Graeme Smith**. arXiv:1007.2855. IEEE Information Theory Workshop Proceedings (2010)
56. *Additive extensions of a quantum channel.* **Graeme Smith**, John Smolin. arXiv:0712.2471. IEEE Information Theory Workshop Proceedings (2008)

Journal Publications

55. *Linear embedding of nonlinear dynamical systems and prospects for efficient quantum algorithms* Alexander Engel, **Graeme Smith**, Scott E Parker. Physics of Plasmas 28, 062305 (2021)
54. *Efficient and Low-Backaction Quantum Measurement Using a Chip-Scale Detector.* Eric I Rosenthal, Christian MF Schneider, Maxime Malnou, Ziyi Zhao, Felix Leditzky, Benjamin J. Chapman, Waltraut Wustmann, Xizheng Ma, Daniel A. Palken, Maximilian F. Zanner, Leila R. Vale, Gene C. Hilton, Jiansong Gao, **Graeme Smith**, Gerhard Kirchmair, and KW Lehnert. Phys. Rev. Lett. 126, 090503 (2021)

53. *Asymptotic performance of port-based teleportation*. Matthias Christandl, Felix Leditzky, Christian Majenz, **Graeme Smith**, Florian Speelman, Michael Walter. *Communications in Mathematical Physics* 381 (1), 379-451 (2021)
52. *Multipartite Optimized Correlation Measures and Holography*. Oliver DeWolfe, Joshua Levin, **Graeme Smith**. *Physical Review D* 102 (6), 066001 (2020)
51. *Monotonicity Under Local Operations: Linear Entropic Formulas*. Mohammed Alhejji and **Graeme Smith**. *IEEE Transactions on Information Theory*, 66, 8, 5055-5060 (2020)
50. *Optimized Measures of Bipartite Quantum Correlation*. Josh Levin and **Graeme Smith**. *IEEE Transactions on Information Theory*, 66, 6, 3520-3526 (2020)
49. *Correlation measures and distillable entanglement in AdS/CFT*. Joshua Levin, Oliver DeWolfe and **Graeme Smith**. *Physical Review D* 101 (4), 046015 (2020)
48. *Playing Games with Multiple Access Channels*. Felix Leditzky, Mohammad Alhejji, Joshua Levin, **Graeme Smith**. *Nature Communications* 11, 1497 (2020).
47. *A Quantum Algorithm for the Vlasov Equation*. Alex Engel, **Graeme Smith** and Scott Parker. *Physical Review A* 100 (6), 062315 (2019)
46. *Unitary-projective entanglement dynamics*. Amos Chan, Rahul Nandkishore, Michael Pretko and **Graeme Smith**. *Physical Review B* 99 (22), 224307 (2019)
45. *Dephasing Channel and Superadditivity of Coherent Information*. Felix Leditzky, Debbie Leung and **Graeme Smith**. *Physical review letters* 121 (16), 160501 (2018)
44. *Harnessing electro-optic correlations in an efficient mechanical converter*. Higginbotham, A. P., P. S. Burns, M. D. Urmeý, R. W. Peterson, N. S. Kampel, B. M. Brubaker, **G. Smith**, K. W. Lehnert, and C. A. Regal. *Nature Physics* 14, 10, 1038 (2018)
43. *Useful states and entanglement distillation*. Felix Leditzky, Nilanjana Datta, and **Graeme Smith**. *IEEE Transactions on Information Theory* 64, 7, 4689-4708 (2018)
42. *Quantum and private capacities of low-noise channels*. Felix Leditzky, Debbie Leung, **Graeme Smith**. *Phys. Rev. Lett.* 120, 160503 (2018)
41. *Uniform Additivity in Classical and Quantum Information*. Andrew W. Cross, Ke Li, **Graeme Smith**. *Phys. Rev. Lett.* 118, 040501 (2017)
40. *Trading classical and quantum computational resources*. Sergey Bravyi, **Graeme Smith** and John Smolin. *Phys. Rev. X* 6 (2), 021043 (2016)
39. *Quantum de Finetti theorem measured with fully one-way LOCC norm*. Ke Li and **Graeme Smith**. *Phys. Rev. Lett.* 114, 160503 (2015)
38. *Quantum learning robust to noise*. Andrew W. Cross, **Graeme Smith** and John A. Smolin. *Phys. Rev. A* 92, 012327 (2015)
37. *New Constructions of Codes for Asymmetric Channels via Concatenation*. Markus Grassl, Peter Shor, **Graeme Smith**, John A. Smolin and Bei Zeng. *IEEE Trans. Info. Theory* 61 (4), 1879-1886 (2015)
36. *Classical signature of quantum annealing*. John Smolin and **Graeme Smith**. *Front. Phys.* 2:52. (2014)
35. *Maximal Privacy without Coherence*. Debbie Leung, Ke Li, **Graeme Smith**, John Smolin. *Phys. Rev. Lett.* 113, 030502 (2014)

34. *Bound entangled states with secret key and their classical counterpart.* Maris Ozols, **Graeme Smith** and John Smolin. *Phys. Rev. Lett.* 112, 110502 (2014)
33. *The entropy power inequality for quantum systems*, Robert Koenig and **Graeme Smith**. *IEEE Trans. Info. Theory*, 60, 3, 1536 - 1548 (2014)
32. *An exactly solvable model of quantum communications*. **Graeme Smith** and John Smolin. *Nature* 504, 263-267 (2013)
31. *Putting "Quantumness" to the Test.* **Graeme Smith** and John Smolin. *Physics* 6, 105 (2013)
30. *Oversimplifying quantum factoring.* John Smolin, **Graeme Smith** and Alexander Vargo. *Nature* 499, 163-165 (2013)
29. *Limits on classical communication from quantum entropy power inequalities*. Robert Koenig and **Graeme Smith**. *Nature Photonics* 7, 142-146 (2013)
28. *The classical capacity of quantum thermal noise channels to within 1.45 bits*. Robert Koenig and **Graeme Smith**. *Phys. Rev. Lett.* 110, 040501 (2013)
27. *Entanglement distillation by means of k-extendible maps.* Lukasz Pankowski, Fernando Brandao, Michal Horodecki, **Graeme Smith**. *QIC* 13, 751 (2013)
26. *Detecting Incapacity of a Quantum Channel.* **Graeme Smith** and John Smolin. *Phys. Rev. Lett.* 108, 230507 (2012)
25. *Efficient Method for Computing the Maximum-Likelihood Quantum State from Measurements with Additive Gaussian Noise.* John A. Smolin, Jay M. Gambetta, and **Graeme Smith**. *Phys. Rev. Lett* 108, 070502 (2012)
24. *An Extreme form of Superactivation for Quantum Zero-Error Capacities*. Toby Cubitt, **Graeme Smith**. *IEEE Trans. Info. Theory*, 58, 3, 1953 - 1961 (2012)
23. *Entanglement can completely defeat quantum noise*. Jianxin Chen, Toby S. Cubitt, Aram Harrow, **Graeme Smith**. *Phys. Rev. Lett.* 107, 250504 (2011)
22. *Quantum communication with Gaussian channels of zero quantum capacity.* **Graeme Smith**, John Smolin, Jon Yard. *Nature Photonics* 5, 624-627 (2011)
21. *High performance single-error-correcting quantum codes for amplitude damping.* Peter W. Shor, **Graeme Smith**, John A. Smolin, Bei Zeng. *IEEE Trans. Info. Theory* 57, 10, 7180-7188 (2011)
20. *Can closed timelike curves or nonlinear quantum mechanics improve quantum state discrimination or help solve hard problems?* Charles H. Bennett, Debbie Leung, **Graeme Smith**, John Smolin. *Phys. Rev. Lett.* 103, 170502 (2009)
19. *Extensive nonadditivity of privacy.* **Graeme Smith**, John Smolin. *Phys. Rev. Lett.* 103, 120503 (2009)
18. *Continuity of Quantum Channel Capacities.* Debbie Leung, **Graeme Smith**. *Comm. Math. Phys.* 292, 1, 201-215 (2009)
17. *Generalized concatenated quantum codes.* Markus Grassl, Peter Shor, **Graeme Smith**, John Smolin, Bei Zeng. *Phys. Rev. A* 79, 050306(R) (2009)
16. *Codeword stabilized quantum codes: algorithm and structure.* Isaac Chuang, Andrew Cross, **Graeme Smith**, John Smolin, Bei Zeng. *J. Math. Phys.* 50, 042109 (2009)

15. *Can non-private channels transmit quantum information?* **Graeme Smith**, John Smolin. Phys. Rev. Lett. 102, 010501 (2009)
14. *Codeword stabilized quantum codes.* Andrew Cross, **Graeme Smith**, John Smolin, Bei Zeng. IEEE Trans. Info. Theory 55, 1, 433-438 (2009)
13. *The structure of degradable quantum channels.* Toby Cubitt, Mary-Beth Ruskai, **Graeme Smith**. J. Math. Phys. 49, 102104 (2008)
12. *Quantum communication with zero-capacity channels.* **Graeme Smith**, Jon Yard. Science 321, 1812-1815 (2008)
11. *The quantum capacity with symmetric side-channels.* **Graeme Smith**, John Smolin, Andreas Winter. IEEE Trans. Info. Theory 54, 9, 4208-4217 (2008)
10. *The private classical capacity with a symmetric side channel and its application to quantum cryptography.* **Graeme Smith**. Phys. Rev. A 78, 022306 (2008)
9. *Structured codes improve the Bennett-Brassard-84 quantum key rate.* **Graeme Smith**, Joseph Renes, John Smolin. Phys. Rev. Lett. 100, 170502 (2008)
8. *Communicating over adversarial quantum channels using quantum list codes.* Debbie Leung, **Graeme Smith**. IEEE Trans. Info. Theory 54, 2, 883-887 (2008)
7. *A simple family of nonadditive quantum codes.* John Smolin, **Graeme Smith**, Stephanie Wehner. Phys. Rev. Lett. 99, 130505 (2007)
6. *Degenerate quantum codes for Pauli channels.* **Graeme Smith**, John Smolin. Phys. Rev. Lett. 98, 030501 (2007)
5. *Noisy processing and the distillation of private quantum states.* Joseph Renes, **Graeme Smith**. Phys. Rev. Lett. 98, 020502 (2007)
4. *Typical entanglement in stabilizer states.* **Graeme Smith**, Debbie Leung. Phys. Rev. A 74, 062314 (2006)
3. *Optimal superdense coding of entangled states.* Anura Abeyesinghe, Patrick Hayden, **Graeme Smith**, Andreas Winter. IEEE Trans. Info. Theory 52, 8, 3635-3641 (2006)
2. *Multiparty data hiding of quantum information.* Patrick Hayden, Debbie Leung, **Graeme Smith**. Phys. Rev. A 71, 062339 (2005)
1. *Large-area mapping at 850 microns. II. Analysis of the clump distribution in the rho Ophiuchi molecular cloud.* Doug Johnstone, Christine D. Wilson, Gerald Moriarty-Schieven, Gilles Joncas, **Graeme Smith**, Erik Degersén, and Michel Fich. The Astrophysical Journal, 545, 1, 327-339 (2001)