



Patrick Hayden

School of Computer Science

McGill University

Montreal, Quebec, Canada H3A 2A7

phone (514)398-5491 • email patrick@cs.mcgill.ca

Appointments

- 2008- **McGill University** **Montreal, Canada**
Associate Professor of Computer Science
- 2005- **Perimeter Institute for Theoretical Physics** **Waterloo, Ontario**
Affiliate Member
- 2005- **McGill University** **Montreal, Canada**
Associate Member, Physics Department
- 2004-2008 **McGill University** **Montreal, Canada**
Assistant Professor of Computer Science
- 2001-2004 **California Institute of Technology** **Pasadena, USA**
Sherman Fairchild Prize Postdoctoral Fellow

Education

- 1998-2001 **University of Oxford** **Oxford, UK**
D. Phil. Physics (Rhodes Scholar)
Thesis: Distributing Quantum Information
Supervisor: Artur Ekert
- 1994-1998 **McGill University** **Montreal, Canada**
B. Sc. (Hon.) Mathematics and physics (GPA 3.99)
Thesis: Formulas for Symplectic Volumes of Moduli Spaces
Supervisor: Lisa Jeffrey
- 1989-1994 **Sir Robert Borden High School** **Ottawa, Canada**
Valedictorian (GPA 4.00)

Honors and Awards

- Alfred P. Sloan Foundation:
 - 2007- **Sloan Research Fellowship in Computer Science**
- Government of Canada:
 - 2005- **Canada Research Chair in the Physics of Information**
- Canadian Institute for Advanced Research:
 - 2004- **Scholar: Quantum Information Processing Program**

- Los Alamos National Laboratory:
 - 2004 **J. Robert Oppenheimer Fellowship** (Declined)
- California Institute of Technology:
 - 2001-2004 **Sherman Fairchild Prize Fellowship**
- University of Oxford:
 - 1998-2001 **Rhodes Scholarship**
- McGill University:
 - 1998 **Anne Molson Gold Medal** (For highest standing in mathematics & physics)
 - 1998 **Horace Watson Medal and Prize** (For highest standing in physics)
 - 1997 **James Mathison Scholarship** (For academic standing in honours physics)
 - 1996 **Stuart Foster Prize** (For academic standing in physics)
 - 1994-1998 **Greville Smith Scholarship** (Tuition, expenses and stipend)
- For work at QNX software:
 - 1996 **EDN Magazine Innovation of the Year Finalist**
 - 1995 **BYTE Magazine Editor's Award of Distinction**
 - 1995 **Paris Real-Time Systems Exhibition Prix Fournisseur**

Presentations

- **Invited conference presentations:**

▪ 2008	Texas Symposium on Astrophysics	Vancouver
▪ 2008	Canadian Mathematical Society (Public Lecture)	Ottawa
▪ 2008	CERN Black Hole Institute	Geneva
▪ 2008	Bellairs Workshop on Logic, Physics and Information	Barbados
▪ 2008	Gordon Research Conference on Quantum Information	Montana
▪ 2008	IEEE Information Theory Workshop	Porto
▪ 2008	Southwest Quantum Information (SQuInT) Conference	Santa Fe
▪ 2008	LANL Classical and Quantum Information Workshop	Santa Fe
▪ 2007	Quantum Information Theory in Quantum Gravity	Perimeter Institute
▪ 2007	QuantumWorks Annual Meeting	Calgary
▪ 2007	Quantum Information Processing	New Delhi, India
▪ 2007	28 th Conference on Quantum Probability and Related Topics	Guanajuato, Mexico
▪ 2007	Randomization of Quantum Systems	Waterloo
▪ 2007	Dept. of Combinatorics and Optimization 40 th Anniversary	Waterloo
▪ 2007	Operator Structures in Quantum Information	BIRS, Banff
▪ 2006	Workshop on Quantum Cryptography and Computing	Fields Institute
▪ 2006	International Congress of Mathematical Physics	Rio de Janeiro
▪ 2006	Symposium on Mathematical Physics	Torun, Poland
▪ 2005	Benasque Center Quantum Information Workshop	Benasque, Spain
▪ 2005	CMS June Meeting	Waterloo
▪ 2005	APS March Meeting	Los Angeles
▪ 2005	Quantum Information Processing	Boston
▪ 2004	CIFAR Quantum Information Processing Workshop	Montebello, QC
▪ 2004	Quantum Communication, Measurement and Computing	Glasgow, UK
▪ 2003	ERATO Conference on Quantum Information Theory	Kyoto, Japan

- 2002 Quantum Information Processing Berkeley
- 2002 MSRI Workshop on Quantum Information Theory Berkeley
- 2002 AMS Fall Meeting, Quantum Information Session Boston
- 2002 AMS Winter Meeting, Quantum Information Session San Diego
- 2002 Quantum Foundations in Light of Quantum Information Montreal
- 2000 IEE Meeting on Nanotechnology and Quantum Computing Winchester, UK
- 2000 Quantum Foundations in Light of Quantum Information Montreal
- 2000 Quantum Communication, Measurement and Computing Capri, Italy
- 2000 Quantum Algorithms and Information Processing Workshop Amsterdam
- **Contributed conference presentations:**
 - 2006 Quantum Information Processing Paris
 - 2006 CIFAR Quantum Information Processing Workshop Lac Sacacomie, QC
 - 2003 Quantum Information Processing IBM Yorktown
- **Seminars and colloquia:**
 - Caltech, *Institute for Quantum Information Seminar* (2005, 2002, 2001)
 - Cambridge University, *Centre for Quantum Computation Seminar* (2006)
 - IBM Research, *Physics of Information Seminar* (2003, 2002, 2000)
 - Los Alamos National Lab, *Quantum Lunch* (2002, 2001, 2000)
 - McGill University, *Physics Colloquium* (2006), *High Energy Physics Seminar* (2008)
 - McGill University, *Centre for Nonlinear Dynamics in Physiology and Medicine Seminar* (2005)
 - McGill University, *Computer Science Colloquium* (2004, 2001)
 - MIT, *Quantum Information Seminar* (2007, 2005, 2002)
 - Perimeter Institute, *Various Seminar Series* (2007, 2006, 2003)
 - Queen's University, *Mathematics Colloquium* (2007)
 - Rutgers University, *High-energy theory seminar* (2008)
 - Stanford University, *Institute for Theoretical Physics Seminar* (2008)
 - UC Berkeley, *Quantum Information Seminar* (2002)
 - University of Bristol, *Quantum Information Seminar* (2006, 2002)
 - University of Calgary, *Institute for Quantum Information Science Seminar* (2007)
 - University of Michigan, *General Dynamics Distinguished Lecture Series* (2006)
 - University of New Mexico, *Center for Advanced Studies Seminar* (2007, 2000)
 - University of Sherbrooke, *Condensed Matter Seminar* (2007)
 - University of Southern California, *Communication Sciences Institute Seminar* (2005)
 - University of Toronto, *Quantum Information Seminar* (2007, 2003)
 - University of Waterloo, *Applied Math Colloquium* (2004)
 - University of Waterloo, *Institute for Quantum Computing Seminar* (2001)
 - York University, *Physics Colloquium* (2005)

Publications

Refereed journal articles (published and in press):

- Jon Yard, Patrick Hayden, Igor Devetak. Quantum broadcast channels. To appear in *IEEE Trans. Inform. Th.*
- Frédéric Dupuis and Patrick Hayden. A father protocol for quantum broadcast channels. . To appear in *IEEE Trans. Inform. Th.*

- Jon Yard, Igor Devetak and Patrick Hayden. Capacity theorems for quantum multiple access channels - Classical-quantum and quantum-quantum capacity regions. *IEEE Trans. Inform. Th.* 54(7):3091-3113, 2008.
- Andreas Winter and Patrick Hayden. Counterexamples to the maximal p -norm multiplicativity conjecture for all $p > 1$. *Comm. Math. Phys.* 284(1):263-280, 2008.
- Cory Dean, Benjamin Piot, Patrick Hayden, Sankar Das Sarma, Guillaume Gervais, Loren Pfeiffer and Ken West. Contrasting behavior of the $5/2$ and $7/3$ fractional quantum Hall effect in a tilted field. *Phys. Rev. Lett.* 101:186806, 2008.
- Harry Buhrman, Matthias Christandl, Patrick Hayden, Hoi-Kwong Lo and Stephanie Wehner. Possibility, impossibility and cheat-sensitivity of quantum bit string commitment. *Phys. Rev. A* 78:022316.
- Cory Dean, Benjamin Piot, Patrick Hayden, Sankar Das Sarma, Guillaume Gervais, Loren Pfeiffer and Ken West. Intrinsic gap of the $\nu=5/2$ fractional quantum Hall state. *Phys. Rev. Lett.* 100:146803, 2008.
- Patrick Hayden, Michal Horodecki, Andreas Winter and Jon Yard. A decoupling approach to the quantum capacity. *Open Systems and Information Dynamics*. 15:7-19, 2008.
- Patrick Hayden, Peter Shor and Andreas Winter. Random quantum codes from Gaussian ensembles and an uncertainty relation. *Open Systems and Information Dynamics*. 15:71-89, 2008.
- Patrick Hayden and John Preskill. Black holes as mirrors: Quantum information in random subsystems. *Journal of High Energy Physics* 09:120, 2007.
- David Avis, Patrick Hayden and Ivan Savov. Distributed compression and multiparty squashed entanglement. *J. Phys. A*. 41:115301, 2008.
- Harry Buhrman, Matthias Christandl, Patrick Hayden, Hoi-Kwong Lo and Stephanie Wehner. Security of quantum bit string commitment depends on the information measure. *Phys. Rev. Lett.* 97:250501, 2006.
- Anura Abeyesinghe, Patrick Hayden, Graeme Smith and Andreas Winter. Optimal superdense coding of entangled states. *IEEE Trans. Inf. Th.* 52(8):3635-3641, 2006.
- Patrick Hayden, Debbie Leung and Andreas Winter. Aspects of generic entanglement. *Commun. Math. Phys.* 265(1):95-117, 2006.
- Charlene Ahn, Andrew Doherty, Patrick Hayden and Andreas Winter. On the distributed compression of quantum information. *IEEE Trans. Inf. Th.* 52(10):4349-4357, 2006.
- Stephen D. Bartlett, Patrick Hayden and Robert W. Spekkens. Random subspaces for encryption based on a private shared Cartesian frame. *Phys. Rev. A*, 72:052329, 2005.
- Harry Buhrman, Matthias Christandl, Patrick Hayden, Hoi-Kwong Lo and Stephanie Wehner. On the (im)possibility of quantum string commitment. To appear in *Phys. Rev. A*. arXiv:quant-ph/0504078, 2005.
- Sumit Daftuar and Patrick Hayden. Quantum state manipulations and the Schubert calculus. *Ann. Phys.* 315(1):80-122, 2005.
- Charles Bennett, Patrick Hayden, Debbie Leung, Peter Shor, and Andreas Winter. Remote preparation of quantum states. *IEEE. Trans. Inf. Th.* 51(1):56-74, 2005.

- Patrick Hayden and Christopher King. Correcting quantum channels by measuring the environment. *Quantum Information and Computation* 5(2):156-160, 2005.
 - Patrick Hayden, Debbie Leung and Graeme Smith. Multiparty data hiding of quantum information. *Phys. Rev. A*, 71:062339, 2005.
 - Aram Harrow, Patrick Hayden and Debbie Leung. Superdense coding of quantum states. arXiv:quant-ph/0307221. *Phys. Rev. Lett.* 92:187901, 2004.
 - Patrick Hayden, Debbie Leung, Peter Shor, and Andreas Winter. Randomizing quantum states: Constructions and applications. *Commun. Math. Phys.* 250(2):371-391, 2004.
 - Patrick Hayden, Richard Jozsa, Denes Petz and Andreas Winter. Conditions for equality in the strong subadditivity inequality for quantum entropy. *Commun. Math. Phys.* 246(2):359-374, 2004.
 - Anura Abeyesinghe and Patrick Hayden. Generalized remote state preparation: Trading cbits, qubits and ebits in quantum communication. *Phys. Rev. A* 68:062319, 2003.
 - David D. DiVincenzo, Patrick Hayden and Barbara M. Terhal. Hiding quantum data. *Found. Phys.* 33(11):1629-164, 2003.
 - Wim van Dam and Patrick Hayden. Embezzling entangled quantum states (Universal entanglement transformations without communication). *Phys. Rev. A* 67:060302, 2003.
 - Patrick Hayden and Andreas Winter. On the communication cost of entanglement transformations. *Phys. Rev. A* 67:012326, 2003.
 - Patrick Hayden, Richard Jozsa and Andreas Winter. Trading quantum and classical resources in quantum data compression. *J. Math. Phys.* 43(9):4404-4444, 2002.
 - Howard Barnum, Patrick Hayden, Richard Jozsa and Andreas Winter. On the reversible extraction of information from a quantum source. *Proc. R. Soc. Lond. A*, 457(2012):2019-2039, 2001.
 - Simon C. Benjamin and Patrick Hayden. Comment on “Quantum games and quantum strategies”. *Phys. Rev. Lett.*, 87:069801, 2001.
 - Simon C. Benjamin and Patrick Hayden. Multiplayer quantum games. *Phys. Rev. A*, 64:030301, 2001.
 - Artur Ekert, Patrick Hayden, Hitoshi Inamori, and Daniel Oi. What is quantum computation? *Int. J. Mod. Phys. A*, 16(20):3335-3363, 2001.
 - Patrick Hayden, Michal Horodecki, and Barbara M. Terhal. The asymptotic entanglement cost of preparing a quantum state. *J. Phys. A*, 34(35):6891-6898, 2001.
 - David Deutsch and Patrick Hayden. Information flow in entangled quantum systems. *Proc. R. Soc. Lond. A*, 456(1999):1759-1774, 2000.
 - Artur Ekert, Marie Ericsson, Patrick Hayden, Hitoshi Inamori, Jonathan Jones, Daniel Oi, and Vlatko Vedral. Geometric quantum computation. *J. Mod. Optics*, 47(14/15):2501-2513, 2000.
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Refereed conference proceedings:

- David Avis, Patrick Hayden and Ivan Savov. Multipartite distributed compression of quantum information. In *Proceedings of the Second International Conference on Quantum, Nano and Micro Technologies*. IEEE, 2008. In press.
 - Jon Yard, Patrick Hayden and Igor Devetak. Quantum broadcast channels. arXiv:quant-ph/0603098, 2006. In *Proceedings of the ERATO Conference on Quantum Information Science, Tokyo, Japan*, 2005.
 - Jon Yard, Igor Devetak, Patrick Hayden. Capacity theorems for quantum multiple access channels In *Proceedings of the 2005 IEEE Symposium on Information Theory, Adelaide, Australia*, pp. 884-888, 2005.
 - Jon Yard, Igor Devetak, Patrick Hayden. Sending classical and quantum information over quantum multiple access channels. In *Proceedings of the ninth Canadian Workshop on Information Theory, Montreal, Canada*. pp. 387-390, 2005.
 - Patrick Hayden. Entanglement in random subspaces. In *Proceedings of the Seventh International Conference on Quantum Communication, Measurement and Computing*. American Institute of Physics. pp. 226-229, 2004.
 - Artur Ekert, Patrick Hayden, and Hitoshi Inamori. Basic concepts in quantum computation. In R. Kaiser, C. Westbrook, and F. David, editors, *Proceedings of the 1999 Les Houches summer school on "Coherent Matter Waves"*, volume 72, pp. 661-703, 2001.
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Preprints on arXiv.org:

- Kamil Bradler, Patrick Hayden and Prakash Panangaden. Private information via the Unruh effect. arXiv.org:0807.4536, 2008.
 - Patrick Hayden. The maximal p -norm multiplicativity conjecture is false. arXiv:0707.3291, 2007.
 - Anura Abeyesinghe, Igor Devetak, Patrick Hayden and Andreas Winter. The mother of all protocols: Restructuring quantum information's family tree. arXiv:quant-ph/0606225, 2006.
 - Robin Blume-Kohout and Patrick Hayden. Accurate quantum state estimation via "Keeping the experimentalist honest." arXiv:quant-ph/0603116, 2006.
 - Wim van Dam and Patrick Hayden. Renyi-entropic bounds on quantum communication. arXiv:quant-ph/0204093, 2002.
 - Patrick Hayden, Barbara M. Terhal, and Armin Uhlmann. On the LOCC classification of bipartite density matrices. arXiv:quant-ph/0011095, 2000.
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Refereed book chapters:

- P. Hayden. Capacities enhanced by entanglement. In *Encyclopedia of Mathematical Physics*, eds. J.-P. Francoise, G.L. Naber and S.T. Tsou, pp. 418-424. Elsevier, 2006.
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Popularized texts:

- P. Hayden. Putting certainty in the bank. *Nature* 436:633-634, 2005.
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Patents

- Patrick M. Hayden and Robin Burgener. Window Kernel. United States Patent 5,745,759. Granted April 28, 1998.