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# Lorenza Viola

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<http://www.dartmouth.edu/~viola/index.html>

## EDUCATION

### **Ph.D., Physics, University of Padova (Italy)**

October 1996. Thesis: “Relativistic stochastic quantization through co-moving coordinates.”  
Advisor: Prof. Laura M. Morato, University of Verona (Italy).

### **M.S., Physics, University of Trento (Italy)**

December 1991, *Laurea Summa Cum Laude*. Thesis: “Roto-vibrational spectroscopy of linear quadriatomic molecules in the vibron model: monofluoroacetylene.” Advisor: Prof. Francesco Iachello (Yale University).

## PROFESSIONAL EXPERIENCE

- Since 07/04 **Associate Professor of Physics**  
*Dartmouth College*, Department of Physics and Astronomy.
- 06/09 - 07/09 **Visiting Scientist**  
*Santa Barbara*, Kavli Institute for Theoretical Physics.
- 11/08 - 12/08 **Visiting Scientist**  
*Harvard University*, Institute for Theoretical Atomic, Molecular, and Optical Physics.
- 09/07 - 12/07 **Visiting Scientist**  
*Massachusetts Institute of Technology*, Center for Extreme Quantum Information Theory.
- 01/05 - 08/07 **Guest Scientist**  
*Los Alamos National Laboratory*, Computer & Computational Sciences Division.
- 01/02 - 01/05 **J. Robert Oppenheimer Fellow**  
*Los Alamos National Laboratory*, Computer & Computational Sciences Division.
- 08/00 - 12/01 **Director-Funded Postdoctoral Fellow**  
*Los Alamos National Laboratory*, Theoretical Division.  
Research advisors: Dr. Emanuel Knill, Dr. Raymond Laflamme.
- 01/97 - 07/00 **Postdoctoral Fellow**  
*Massachusetts Institute of Technology*, Department of Mechanical Engineering.  
Research advisor: Prof. Seth Lloyd.
- 01/99 - 12/99 **Postdoctoral Research Associate**  
*Northeastern University*, Department of Physics.  
Research advisor: Prof. Srinivas Sridhar.
- 01/93 - 12/96 **Graduate Research Assistant**  
*University of Padova*, Department of Physics.

## RESEARCH INTERESTS

- *Quantum Information Science*: Methods for reliable quantum information processing and robust control of open quantum systems, including dynamical decoupling, quantum error correction, noiseless subsystems, quantum feedback. Fundamental limits of control, quantum metrology. Physical realizations of quantum information. Theory and applications of entanglement.
- *Quantum Statistical Mechanics*: Quantum irreversibility. Decoherence, dissipation, and entanglement in complex quantum systems. Quantum stochastic resonance. Equilibrium and non-equilibrium quantum critical phenomena. Many-body quantum chaos and quantum randomness.
- *Dynamical-Algebraic Methods*: Spectrum generating algebras and quantum integrability. Lie-algebraic and exactly solvable models of interacting quantum many-body systems.
- *Gravitational Physics*: Quantum-mechanical signatures of gravitation on mesoscopic scales. Gravitational decoherence mechanisms. Relativistic quantum information and entanglement.

AWARDS AND HONORS

- 2009 *Linda B. and Kendrick R. Wilson III 1969 Fellowship* for excellence in teaching and research
- 2008 Included in the 2008-09 *Madison Who's Who Among Executive and Professionals*  
Included in the 2008-09 *62nd Edition of Who's Who in America*  
Included in the 2008-09 *Who's Who in Science and Engineering*
- 2007 Included in the 2007-08 *Cambridge Who's Who Among Executive & Professional Women*
- 2006 Included in the 2006-07 *Who's Who in Science and Engineering*
- 2005 Honored Member of the *Empire Who's Who 2005-2006*  
Included in the 2005-06 *Who's Who in Science and Engineering*
- 2002 Awarded J. Robert Oppenheimer Fellowship at LANL
- 2000 Awarded Director-Funded Postdoctoral Fellowship at LANL
- 1998 Selected for full membership in *Sigma Xi, MIT Chapter*
- 1997 Honorable Mention Winner in the competition for *Essays on Gravitation 1997*  
Awarded European Community *Marie Curie* Postdoctoral Fellowship  
Awarded Padova University Graduate Fellowship for research at MIT
- 1993-96 Recipient of Padova University Doctoral Fellowship

GRANTS AWARDED

EXTERNAL FUNDING:

• **Current research grants and contracts**

- 2009-12 National Science Foundation, Physics Division USD 300,000  
*High-Fidelity Quantum Information Processing via Dynamical Quantum Error Control*  
Principal Investigator.
- 2011-14 Army Research Office & National Security Agency USD 343,000  
*Precision Quantum Control and Error-Suppressing Quantum Firmware for Robust Quantum Computing*  
Co-Principal Investigator. (Total grant amount: USD 1,600,182).
- 2011-15 Intelligence Advanced Research Projects Activity USD 468,900  
*Optimized Resources and Architectures for Quantum Algorithms (ORAQL)*  
Co-Principal Investigator. (Total grant amount: USD 16,838,303)
- 2011-14 National Science Foundation, Physics and Computer Science Divisions USD 201,800  
Principal Investigator.

• **Past research grants**

- 2006-09 National Science Foundation, Physics Division USD 180,000  
*Randomized Dynamical Decoupling Techniques for Quantum Information Processing*  
Principal Investigator.
- 2006-09 Department of Energy USD 510,000  
*Modeling, Control, and Diagnostics of Electronic and Nuclear Spins in Nanosystems*  
Co-Principal Investigator. (Total grant amount: USD 1,020,000)

INTERNAL FUNDING:

- 2004-09 Dartmouth College USD 285,000  
*Special Projects Funds in Quantum Information Science*
- 2009 Dartmouth College USD 2,000  
*Faculty Fellowship Award*

SELECTED INVITED TALKS AND LECTURES

(See Page 17 for a complete list)

- 08/12\* Gordon Research Conference on *Quantum Science*, Stonehill College, Easton, MA  
 06/12\* 12th Canadian Summer School on *Quantum Information*, Institute for Quantum Computing and Perimeter Institute for Theoretical Physics, Waterloo, Canada  
 01/12 Annual Meeting of the *American Mathematical Society*, Boston, MA  
 12/11 International Workshop on *Principles and Applications of Quantum Control*, Kavli Royal Society Centre for the Advancement of Science, London, UK  
 12/11 Second International Conference on *Quantum Error Correction*, University of Southern California  
 08/11 Gordon Research Conference on *Quantum Control of Light and Matter*, Mt. Holyoke College, MA  
 05/11 Second Conference on *Difficult Problems in Quantum Information Theory*, Center for Extreme Quantum Information Theory, Massachusetts Institute for Technology  
 07/10 Workshop on *Random Matrix Techniques in Quantum Information Theory*, Perimeter Institute for Theoretical Physics, Waterloo, Canada  
 10/09 First International Workshop on *Dynamical Decoupling*, NIST, Boulder, CO  
 08/09 Gordon Research Conference on *Quantum Control of Light and Matter*, Mt. Holyoke College, MA  
 07/09 KITP Program on *Quantum Control of Light and Matter*, Santa Barbara, CA  
 05/09 QUROPE International School on *Quantum Information and Many-Body Systems*, Cortona, Italy  
 11/08 Conference on *Difficult Problems in Quantum Information Theory*, Center for Extreme Quantum Information Theory, Massachusetts Institute for Technology  
 09/08 Workshop on *Quantum/Classical Control in Quantum Information: Theory and Experiments*, Otranto, Italy (Keynote speaker)  
 08/08 Workshop on *Principles and Applications of Control in Quantum Systems 2008*, Eugene, OR  
 12/07 First International Conference on *Quantum Error Correction*, University of Southern California  
 09/07 Third International IEEE Scientific Conference on *Physics and Control*, Potsdam, Germany  
 07/07 14th International Conference on *Recent Progress in Many-Body Theories*, Barcelona, Spain  
 08/06 Workshop on *Frontiers of Quantum Decoherence*, University of Toronto, Canada  
 08/06 Workshop on *Principles and Applications of Control in Quantum Systems 2006*, Harvard  
 06/06 Workshop on *Theory and Technology in Quantum Information, Communication, Computation, and Cryptography*, ICTP, Trieste, Italy  
 03/06 Boston Colloquium for Philosophy of Science on *Foundations of Quantum Information and Entanglement*, Boston University  
 02/06 Third Workshop on *Decoherence, Entanglement, Information in Complex Systems*, Eilat, Israel  
 01/06 XXXVI Winter Colloquium on *The Physics of Quantum Electronics*, Snowbird, UT  
 12/05 *44th IEEE Conference on Decision and Control & European Control Conference*, Seville, Spain  
 08/05 Workshop on *Recent Developments in Fault-Tolerant Quantum Computation*, IBM Yorktown (Session Chair)  
 08/05 Summer School on *Principles and Applications of Control in Quantum Systems 2005*, Caltech  
 06/05 Workshop on *Quantum Information and Decoherence in Condensed Matter*, Benasque  
 12/04 Workshop on *Quantum Entanglement in Physical and Information Sciences*, Scuola Normale Superiore & Centro Matematico “Ennio De Giorgi”, Pisa, Italy  
 10/04 Workshop on *Quantum Entanglement, Decoherence, Information, and Geometrical Phases in Complex Systems*, ICTP, Trieste, Italy  
 08/04 Second International *Feynman Festival*, College Park, MD  
 07/04 First International Conference on *Quantum Information and Quantum Control*, Fields Institute for Research in Mathematical Sciences, Toronto, Canada (Session Chair)

\* Confirmed

ADDITIONAL INFORMATION

**Languages.** Italian (mother tongue); excellent knowledge of English; good spoken and written knowledge of German (8 years training).

**Personal.** Citizen of Italy and of the United States of America.

PROFESSIONAL AND ORGANIZATIONAL SERVICE OUTSIDE DARTMOUTH

- 2011- Co-organizer of the Conference *New Directions in the Quantum Control Landscape*, Kavli Institute for Theoretical Physics, Santa Barbara (02/2013)  
 Member of the Nominating Committee of for the American Physical Society  
*New England Section* (NESAPS)  
 Vice Chair for the 2013 Gordon Research Conference on *Quantum Control of Light and Matter*  
 Panelist at the Strategic NSF Workshop on *Theoretical Atomic, Molecular and Optical Physics* (08/18-19)  
 Reviewer for the *European Coordinated Research on Long-term Challenges in Information and Communication Sciences and Technologies* (CHIST-ERA)
- 2010 Reviewer for the *John Simon Guggenheim Memorial Foundation Fellowship Competition*  
 Advisory board member for the Second International Conference on *Quantum Error Correction*  
 Co-organizer of the Topical Group Workshop on *Open Quantum Systems and Quantum Control*, Institute for Theoretical Atomic, Molecular and Optical Physics, Harvard (08/2010)  
 Panelist for the *National Science Foundation, Quantum Information Science Program* (03/10-11)
- 2009 Chair of the Nominating Committee for the American Physical Society  
*Topical Group on Quantum Information* (01/09–12/09)
- 2008- Chair of the Executive Committee for the American Physical Society  
*Topical Group on Quantum Information* (01/08–12/08)  
 Co-organizer of the Workshop on *Open Quantum Systems: Decoherence and Control*, Institute for Theoretical Atomic, Molecular and Optical Physics, Harvard (11/2008)  
 Reviewer for the French *Agence Nationale de la Recherche* (ANR)  
 Reviewer for the US *Army Research Office* (ARO)  
 External reviewer for tenure and promotion evaluations
- 2007- Chair Elect of the Executive Committee for the American Physical Society  
*Topical Group on Quantum Information* (01/07–12/07)  
 Board member of the *International Physics And Control Society* (IPACS)  
 Advisory board member for the First International Conference on *Quantum Error Correction*  
 Acting editor for *Quantum Information Processing*  
 Reviewer for the *Natural Sciences and Engineering Research Council of Canada* (NSERC)  
 Reviewer for the *Netherlands Organisation for Scientific Research* (NWO)  
 Reviewer for the *Austrian Science Fund* (FWF)  
 Reviewer for the *US-Israel Binational Science Foundation*
- 2006- Vice Chair of the Executive Committee for the American Physical Society  
*Topical Group on Quantum Information, Concepts, and Computation* (01/06–12/06)  
 Editorial Board member of *Physical Review A*, Quantum Information Section (01/06–12/08)  
 Reviewer for the Laboratory Directed Research & Development Program, Los Alamos (03/23)  
 Member of the *Quantum Optics and Quantum Information* subcommittee for the *Conference on Electro-Optics/Quantum Electronics & Laser Science Conference 2007*  
 Member of *The Mathematical Association of America*
- 2005- Referee for the *Research Corporation* (USA)  
 Panelist for the *National Science Foundation* site visit review to the Physics Frontier Center *FOCUS*, University of Michigan, Ann Arbor (04/26-27)
- 2004 Program committee and editorial board member for the Second International Conference *Physics & Control 2005*
- 2003- Referee for the *Science Foundation Ireland* (Republic of Ireland)
- 2002- Program committee member for the First International Conference *Physics & Control 2003*  
 Panelist for the *National Science Foundation, QuBIC Program* (03/4-5)  
 Member of the *Council on Undergraduate Research*
- 2001- Referee for the *National Science Foundation* (USA)  
 Member of the *American Physical Society*

(Continued)

- 1999- Member of the *American Association for the Advancement of Science*
- 1997- Referee for *Physical Review Letters*, *Physical Review A, B, E, X*, *Nature*, *Nature Physics*, *Europhysics Letters*, *New Journal of Physics*, *Physics Letters A*, *Optics Communications*, *Journal of Physics A, B*, *Journal of Applied Physics*, *Journal of Optics B*, *Physica C, E*, *International Journal of Theoretical Physics*, *International Journal of Modern Physics D*, *IEEE Transactions on Information Theory*, *IEEE Transactions on Automatic Control*, *IEEE Transactions on Nanotechnology*, *International Journal of Control*, *Philosophical Transactions of the Royal Society A*, *Annals of Physics*, *Foundations of Physics*, *Quantum Information and Computation*, *Quantum Information Processing*, *Journal of Statistical Mechanics: theory and experiment*, *Systems and Control Letters*, *Journal of Mathematical Physics*, *Reports on Mathematical Physics*, *Reviews of Modern Physics*, *Proceedings of the National Academy of Sciences*
- 1995- Reviewer for *Mathematical Reviews*

COMMITTEE SERVICE AT DARTMOUTH

**Departmental service:**

- Chair of the Graduate Curriculum Committee (A.Y. 2010-11, 2011-12).
- First-year graduate advisor (A.Y. 2010-11, 2011-12).
- First-year undergraduate advisor (A.Y. 2005-06, 2006-07, 2009-10, 2010-11).
- Member of the search committee for experimental condensed-matter faculty position (current).
- Member of the search committee for experimental condensed-matter faculty position (September 2009–March 2010).
- Member of the committee for Graduate Admission (A.Y. 2004-05; A.Y. 2008-09; A.Y. 2009-10).
- Member of the committee for the Physics Qualifying Exam (September 2004, 2005, 2006, 2007, 2008; Co-chair during 2009, 2011).
- Chair of the committee for Physics and Astronomy Department Colloquia (Fall 2004, Winter 2008, Spring 2011).
- Representative of the Physics Department at the annual *Major Enlightenment* event for first and second year students (October 31, 2006).
- Curriculum development: New graduate-level course in Quantum Information Science, first offered in Spring 2005 as Special Topics course (Phys 122), regular offering from Spring 2008 (Phys 116).

**College service:**

- Member of the Committee on Standards (July 2010 to present).
- Director of the *Quantum Information Science Initiative* at Dartmouth (July 2004–June 2010).
- Member of the search committee for the Director of the *William H. Neukom Institute for the Computational Sciences* (September 2004–February 2006).
- Organizer of a *One-day Quantum Information Science Workshop* at Dartmouth (October 30, 2004).

TEACHING EXPERIENCE

**Past and upcoming courses at Dartmouth:**

Statistical Mechanics (Phys 104) Graduate level core course.	<i>Spring 2011</i>
Quantum Information Science (Phys 116) Graduate level course, open to senior undergraduate students.	<i>Spring 2008, 2010, 2012</i>
Introductory Physics IV (Phys 24) Lower level undergraduate course, requirement for Physics major.	<i>Spring 2007, Winter 2008, 2009, 2010, 2011</i>
Introductory Quantum Mechanics (Phys 42) Lower level undergraduate course, requirement for Physics major.	<i>Summer 2007</i>
Advanced Quantum Mechanics (Phys 103) Graduate level core course.	<i>Spring 2006, 2010, 2012</i>
Intermediate Quantum Mechanics (Phys 91) Upper level undergraduate/beginning graduate level core course.	<i>Winter 2006, 2007, 2009, 2011</i>
Highlights in Quantum Information Science (Phys 122) Graduate level course, <i>New course offering</i> .	<i>Spring 2005</i>
Methods in Applied Mathematics (Phys 100/Engs 100) Graduate level core course ( <i>Joint offering</i> , Physics and Engineering Departments).	<i>Fall 2004, 2005, 2011</i>

**Additional teaching experience:**

Lecturer in Quantum Information International School on “Quantum Information & Many-Body Systems,” Cortona, Italy. One-week mini-course “Generalized entanglement with applications in many-body physics”.	<i>May 2009</i>
Lecturer in Quantum Error Correction University of Southern California. Tutorial on “Decoherence-free subspaces, noiseless subsystems, and dynamical decoupling”.	<i>December 2007</i>
Lecturer in Quantum Information Centro di Ricerca Matematica “Ennio De Giorgi”, Scuola Normale Superiore, Pisa, Italy. One-week mini-course “Concepts in control of open quantum systems and quantum information”.	<i>December 2006</i>
Lecturer in Quantum Control Caltech Summer School on “Principles & Applications of Control in Quantum Systems”. Two-hour mini-course “Fundamentals of Dynamical Decoupling”.	<i>August 2005</i>
Lecturer in Quantum Information Processing Los Alamos Summer School. Taught a three-day mini-course “Introduction to Quantum Information Processing and Quantum Error Correction”.	<i>June 2003</i>
Lecturer in Quantum Information Processing Los Alamos Summer School. Taught a one-day mini-course “Introduction to Quantum Information Processing and Quantum Error Correction”.	<i>July 2002</i>
Lecturer in Quantum Mechanics MIT Independent Activities Period. Taught a one-week mini-course “Open Quantum Systems”.	<i>January 2002</i>
Lecturer in Quantum Computation Los Alamos Summer School. Taught lectures on “Introduction to Quantum Computers”.	<i>July 2001</i>
Lecturer on Quantum Computation Santa Fe 2001 Complex Systems Summer School. Taught a two-day mini-course “Introduction to Quantum Computation: What you could do with a quantum computer if you had one,” as part of the session on <i>Nonstandard Approaches to Computation</i> .	<i>June 2001</i>
Lecturer on Quantum Information Processing Second Student Retreat of the SQuInT Network. Taught a tutorial on “Noiseless Subsystems”.	<i>June 2001</i>
Full-time teacher at “A. Pozzo” Technical High School, Trento (Italy) Taught Mathematics, Physics, and Informatics at high school level in both a classroom and laboratory setting. Graded student performance on written assignments and final examinations.	<i>1992-93</i>

POST-DOCS AND STUDENTS ADVISED AT DARTMOUTH

**Postdoctoral fellows:**

- Lea Ferreira dos Santos. Postdoctoral Fellow in Quantum Information Science, September 2004 to August 2007. [Now Assistant Professor at Yeshiva University, Stern College, New York].
- Wenxian Zhang. Postdoctoral Fellow in Quantum Control and Nanophysics, August 2007 to July 2008. [Now Research Professor in Fudan University, China].
- Kaveh Khodjasteh. Postdoctoral Fellow in Quantum Information Science, January 2008 to December 2011. [Now Research Assistant Professor at Dartmouth].
- Shusa Deng. Postdoctoral Fellow in Condensed Matter Theory. July 2011 to present.

**Graduate students, sole supervisor:**

- Sarah T. Smith. Master in Physics at Dartmouth. Graduated October 2007.
- Winton G. Brown. Ph.D. in Physics at Dartmouth. Awarded a *GAANN Fellowship* for the A.Y. 2006–2007; awarded a *Hull Fellowship* for the A.Y. 2008–2009. Graduated October 2010.
- Shusa Deng. Ph.D. in Physics at Dartmouth. Awarded a *Hull Fellowship* for the A.Y. 2009–2010. Recipient of the *2011 Graduate Research Award*. Graduated June 2011.
- Peter D. Johnson. Second-year graduate student in Physics.

**Graduate students, joint supervisor:**

- Francesco Ticozzi. Ph.D. in Automatic Control at the University of Padova (Italy), co-advisor with Prof. A. Ferrante. Graduated February 2007. [Now Assistant Professor at the University of Padova].

**Graduate students, Ph.D. committee member:**

Qun Wei (Graduated May 2010); Weiwei Xue (Graduated August 2010); Laura Gilbert (Graduated May 2011); Joel Stettenheim (Ph.D. candidate in Physics); Mingyun Yuan (Ph.D. candidate in Physics).

**Undergraduate students:**

- Dhruvo Jyoti. Physics and Mathematics double major at Dartmouth, December 2009 to present. Awarded a *Neukom Scholar Fellowship* for Summer and Fall 2010. Graduated May 2011.
- David J. Starling. Research Experience for Undergraduate Program in Quantum Information Science, Summer 2005. Junior undergraduate from SUNY, Fredonia.

ADDITIONAL SUPERVISION WORK

- Eleanore Chadderdon. Summer student at the Los Alamos Summer School 2002. Senior undergraduate from Harvard University.
- Evan M. Fortunato. Ph.D. in Nuclear Science and Engineering at MIT. Co-advised jointly with Prof. D. G. Cory. Graduated May 2002. [Now a CEO at *AlphaTech*, Boston].
- Aikaterini D. Mandilara. Ph.D. in Physics at the University of Washington in Saint Louis, co-advised jointly with Dr. V. Akulin (CNRS, Orsay). Graduated December 2005.
- Jonathan Hodges. Ph.D. in Nuclear Science and Engineering, MIT. Served as Ph.D. committee member. Graduated August 2007.
- Sergio Boixo. Ph.D. in Physics, University of New Mexico, Albuquerque. Served as Ph.D. committee member. Graduated August 2008.
- Leonardo Banchi. Ph.D. in Physics, University of Florence, Italy. Served as Ph.D. committee member. Graduating in January 2012.

MOST SIGNIFICANT PUBLICATIONS TO DATE

- W. G. Brown and L. Viola, “Exact convergence rates for arbitrary statistical moments of random quantum circuits,” *Physical Review Letters* **104**, 250501/1–4 (2010).

This paper establishes exact results for the convergence properties of arbitrary statistical moments of random quantum circuits to their limiting Haar values. In addition to having significant implications for efficiently generating random quantum states and unitary operators, these results uncover suggestive connections between quantum pseudorandomness, many-body quantum physics, and quantum chaos.
- K. Khodjasteh and L. Viola, “Dynamically error-corrected gates for universal quantum computation,” *Physical Review Letters* **102**, 080501/1–4 (2009).

This paper proposes a general constructive procedure for designing decoherence-suppressed unitary gates on an open quantum system without encoding or measurement overhead. These results allow for a low-level error correction strategy solely based on Hamiltonian engineering using realistic bounded-strength controls and pave the way to substantially reducing implementation requirements for fault-tolerant quantum computing architectures.
- S. Deng, G. Ortiz, and L. Viola, “Dynamical non-ergodic scaling in continuous finite-order quantum phase transitions,” *Europhysics Letters* **84**, 67008/1–6 (2008).

This paper characterizes the emergence of equilibrium dynamical scaling for a broad class of quenches across both isolated quantum critical points and quantum critical regions in a paradigmatic exactly solvable spin model. A key finding is the dependence of non-equilibrium scaling properties upon the time-dependent control path.
- H. Barnum, E. Knill, G. Ortiz, R. Somma, and L. Viola, “A subsystem-independent generalization of entanglement,” *Physical Review Letters* **92**, 107902/1–4 (2004).

This paper introduces a notion of generalized entanglement based on the idea that entanglement is relative to a preferred observable subspace rather than a preferred subsystem decomposition. By going beyond the distinguishable-subsystem framework, generalized entanglement provides a broader setting for information-theoretic studies of entanglement as well as novel tools for probing quantum correlations in condensed-matter systems.
- L. Viola, E. M. Fortunato, M. A. Pravia, E. Knill, R. Laflamme, and D. G. Cory, “Experimental realization of noiseless subsystems for quantum information processing,” *Science* **293**, 2059–2063, September 14, 2001.

This paper reports the first experimental realization of quantum information storage in a noiseless subsystem, via liquid-state nuclear magnetic resonance techniques. Besides verifying the robust behavior of the noiseless subsystem under general collective noise, the implementation successfully demonstrates actual improvement in error-correcting a large class of relevant error models.
- E. Knill, R. Laflamme, and L. Viola, “Theory of quantum error correction for general noise,” *Physical Review Letters* **84**, 2525–2528 (2000).

This paper is significant for two main reasons: first, it expands the applicability of quantum error correction to systems that are not decomposable to qubits or are not subjected to independent noise; second, it discovers the notion of a noiseless subsystem as the most general approach to noise-free information storage. Noiseless subsystems are shown to encompass noiseless subspaces as a special case, and to relate to error-correcting codes via appropriate algebraic mappings.
- L. Viola, E. Knill, and S. Lloyd, “Dynamical decoupling of open quantum systems,” *Physical Review Letters* **82**, 2417–2421 (1999).

This paper establishes the existence of active decoupling methods able to suppress quantum noise in an arbitrary open quantum system. The result paves the way for the development of quantum error suppression strategies, which enable in principle to accomplish noise-protected universal quantum computation without the cost of ancillary memory resources.

COMPLETE LIST OF PUBLICATIONS

**Peer-reviewed articles:**

- 83** F. Ticozzi and L. Viola, “Stabilizing entangled states with quasi-local quantum dynamical semigroups,” *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences* in press (2012).
- 82** S. Deng, L. Viola, and G. Ortiz, “Majorana modes in time-reversal invariant  $s$ -wave topological superconductors,” *Physical Review Letters*, in press (2012).
- 81** D. Hayes, K. Khodjasteh, L. Viola, and M. J. Biercuk, “Reducing sequencing complexity in dynamical quantum error suppression by Walsh modulation,” *Physical Review A* **84**, 062323/1–13 (2011).
- 80** F. Ticozzi, R. Lucchese, P. Cappellaro, and L. Viola, “Hamiltonian control of quantum dynamical semigroups: Stabilization and convergence speed,” arXiv:1101.2452, *IEEE Transactions on Automatic Control*, in press (2011).
- 79** C. Ramanathan, P. Cappellaro, L. Viola, and D. G. Cory, “Experimental characterization of coherent magnetization transport in a one-dimensional spin system,” *New Journal of Physics* **13**, 103015/1–16 (2011).
- 78** K. Khodjasteh, V. V. Dobrovitski, and L. Viola, “Pointer states via engineered dissipation,” *Physical Review A* **84**, 022336/1–21 (2011).
- 77** S. Deng, G. Ortiz, and L. Viola, “Dynamical critical scaling and effective thermalization in quantum quenches: the role of the initial state,” *Physical Review B* **83**, 094304/1–17 (2011). Times cited: 1
- 76** T. Erdélyi, K. Khodjasteh, and L. Viola, “The size of exponential sums on intervals of the real line,” arXiv:1006.4323, *Constructive Approximations* (2011), DOI 10.1007/s00365-011-9135-x.
- 75** P. Cappellaro, L. Viola, and C. Ramanathan, “Coherent information transfer via highly mixed quantum spin chains,” *Physical Review A* **83**, 032304/1–10 (2011). Times cited: 3
- 74** K. Khodjasteh, T. Erdélyi, and L. Viola, “Limits on preserving quantum coherence using multi-pulse control,” *Physical Review A* **83**, Rapid Communication, 020305/1–4 (2011). Times cited: 7
- 73** R. Blume-Kohout, H. K. Ng, D. Poulin, and L. Viola, “Information-preserving structures: A general framework for quantum zero-error information,” *Physical Review A* **82**, 062306/1–25 (2010). Times cited: 3
- 72** W. G. Brown and L. Viola, “Exact convergence rates for arbitrary statistical moments of random quantum circuits,” *Physical Review Letters* **104**, 250501/1–4 (2010). Times cited: 1
- 71** T. E. Hodgson, L. Viola, and I. D’Amico, “Towards optimized suppression of dephasing in systems subject to pulse timing constraints,” *Physical Review A* **81**, 062321/1–16 (2010). Times cited: 8
- 70** K. Khodjasteh, D. A. Lidar, and L. Viola, “Arbitrarily accurate dynamical control in open quantum systems,” *Physical Review Letters* **104**, 090501/1–4 (2010). Times cited: 23
- 69** F. Ticozzi and L. Viola, “Quantum information encoding, protection, and correction from trace-norm isometries,” *Physical Review A* **81**, 032313/1–9 (2010). Times cited: 3
- 68** S. Deng, G. Ortiz, and L. Viola, “Anomalous non-ergodic scaling in adiabatic multicritical quantum quenches,” *Physical Review B* **80**, Rapid Communication, 241109/1–4 (2009). Times cited: 10
- 67** W. Zhang, P. Cappellaro, N. Antler, B. Pepper, D. G. Cory, V. V. Dobrovitski, C. Ramanathan, and L. Viola, “NMR multiple quantum coherences in quasi-one-dimensional spin systems: Comparison to ideal spin-chain dynamics,” *Physical Review A* **80**, 052323/1-16 (2009). Selected for the *Virtual Journal of Nanoscale Science & Technology* **20**, (November 2009) and the *Virtual Journal of Quantum Information* **9** (December 2009). Times cited: 6
- 66** K. Khodjasteh and L. Viola, “Dynamical quantum error correction of unitary gates with bounded controls,” *Physical Review A* **80**, 032314/1-19 (2009). Selected for the *Virtual Journal of Quantum Information* **9** (September 2009). Times cited: 12

- 65 F. Ticozzi and L. Viola, “Analysis and synthesis of attractive quantum Markovian dynamics,” *Automatica* **45**, 2002–2009 (2009). Times cited: 9
- 64 K. Khodjasteh and L. Viola, “Dynamically error-corrected gates for universal quantum computation,” *Physical Review Letters* **102**, 080501/1–4 (2009). Selected for the *Virtual Journal of Quantum Information* **9** (March 2009). Times cited: 24
- 63 T. E. Hodgson, L. Viola, and I. D’Amico, “Effect of quantum dot shape on dynamical dephasing suppression in exciton qubits under applied electric field,” *Microelectronics Journal* **40**, 502–504 (2009).
- 62 S. Deng, G. Ortiz, and L. Viola, “Dynamical non-ergodic scaling in continuous finite-order quantum phase transitions,” *Europhysics Letters* **84**, 67008/1–6 (2008). Times cited: 21
- 61 Y. S. Weinstein, W. G. Brown, and L. Viola, “Parameters of pseudo-random quantum circuits,” *Physical Review A* **78**, 052332/1–16 (2008). Times cited: 2
- 60 F. Ticozzi and L. Viola, “Quantum Markovian subsystems: Invariance, attractivity, and control,” *IEEE Transactions of Automatic Control* **53**, 2048–2063 (2008). Times cited: 22
- 59 T. E. Hodgson, L. Viola, and I. D’Amico, “Decoherence-protected storage of exciton qubits through ultrafast multipulse control,” *Physical Review B* **78**, 165311/1–12 (2008). Times cited: 11
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**Total citing articles : 1,556**  
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NEWS, PRESS RELEASES, AND MISCELLANEA

- Publication “Pointer states via engineered dissipation,”  
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 COMPLETE LIST OF INVITED TALKS, SEMINARS, AND COLLOQUIA
 

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- 88 “Quantum state stabilization with Markovian dissipative dynamics”  
 – Annual Meeting of the American Mathematical Society, Boston, MA, January 7, 2012  
 – Royal Society Theo Murphy International Meeting on *Principles and applications of quantum control engineering*, Kavli Royal Society International Centre, Chicheley Hall, UK, December 13, 2011
- 86 “Towards optimal constructions of dynamically corrected gates”  
 Second International Conference on *Quantum Error Correction*,  
 University of Southern California, Los Angeles, CA, December 5, 2011
- 85 “Pointer state engineering”  
 Workshop on *Difficult Problems in Quantum Information Theory*,  
 Keck Center for *Extreme Quantum Information Theory*, MIT, Cambridge, MA, May 3, 2011
- 84 “Random matrices from random quantum circuits: Convergence rates for arbitrary statistical moments”  
 Workshop on *Random Matrix Techniques in Quantum Information Theory*,  
 Perimeter Institute for Theoretical Physics, Waterloo, Canada, July 4, 2010
- 83 “Dynamical quantum error correction: Advances and frontiers”  
 Gordon Research Conference on *Quantum Control of Light & Matter*,  
 Mt. Holyoke College, MA, August 5, 2009
- 82 “Dynamical quantum error correction: From dynamical decoupling to  
 dynamically corrected universal quantum gates”  
 – International Workshop on *Dynamical Decoupling*, NIST, Boulder, CO, October 6, 2009  
 – Kavli Institute for Theoretical Physics, Santa Barbara, CA, July 10, 2009
- 80 “Untangling entanglement: An observer-dependent perspective”  
*Colloquium*, Perimeter Institute for Theoretical Physics, Waterloo, Canada, April 8, 2009
- 79 “Dynamically error-corrected universal quantum gates”  
 Workshop on *Difficult Problems in Quantum Information Theory*,  
 Keck Center for *Extreme Quantum Information Theory*, MIT, Cambridge, MA, November 18, 2008
- 78 “Open-loop quantum error control: From dynamical decoupling to  
 dynamically corrected universal quantum gates ”  
 – *Princeton Center for Theoretical Science, Quantum Computing Seminar Series*,  
 Princeton, NJ, February 12, 2009  
 – *Center for Advanced Studies*, University of New Mexico, Albuquerque, NM, December 11, 2008  
 – Sandia National Laboratories, Albuquerque, NM, December 10, 2008  
 – Workshop on *Quantum/Classical Control in Quantum Information: Theory and Experiments*,  
 Otranto, Italy, September 12, 2008
- 74 “Dynamically error-corrected gates for accurate quantum control and computation”  
 – *Physics and Engineering Seminar Series*, University of Massachusetts, Boston, October 22, 2008  
 – *Information Engineering Seminar*, University of Padova, Italy, September 9, 2008  
 – Workshop on *Principles and Applications of Control in Quantum Systems*,  
 Eugene, OR, August 25, 2008
- 71 “Towards quantum control of quantum information systems”  
 – Public lecture, University of Camerino, Italy, May 19, 2009  
 – *Jones Seminars on Science, Technology, and Society*  
 Thayer School of Engineering, Dartmouth College, NH, April 18, 2008
- 69 “Introduction to decoherence-free subspace, noiseless subsystems, and dynamical decoupling”  
 Invited tutorial, First International Conference on *Quantum Error Correction*,  
 University of Southern California, Los Angeles, CA, December 17, 2007

- 68 “A quantum-entangled view to quantum critical phenomena”  
– *Physics Club Colloquium*, Yale University, CT, November 2, 2007  
– *Joint Atomic Physics Colloquium*, Institute for Theoretical Atomic and Molecular Physics, and Harvard University, Cambridge, MA, February 13, 2008
- 66 “Generalized entanglement in static and dynamic quantum phase transitions”  
– *Joint Quantum Institute*, University of Maryland, College Park, MD, February 4, 2008  
– 14th International Conference on *Recent Progress in Many Body Theories*, Barcelona, Spain, July 19, 2007
- 64 “Physical and information-theoretic aspects of generalized entanglement”  
– Quantum Information Science Seminar, MITRE corporation, Eatontown, NJ, August 27, 2007  
– *Special Quantum Information Science Seminar*, MIT, Cambridge, MA, May 16, 2007
- 62 “(Some) principles and applications of quantum information control: Toward a subsystem-theoretic approach?”  
– *Atomic Physics Seminar Series*, Institute for Theoretical Atomic and Molecular Physics, Harvard, Cambridge, MA, June 25, 2007  
– *Center for Advanced Studies*, University of New Mexico, Albuquerque, NM, April 26, 2007  
– Keck Center for *Extreme Quantum Information Theory*, MIT, Cambridge, MA, April 17, 2007
- 59 “Dynamical decoupling techniques for coherent quantum control: Recent developments”  
– Third International Conference on *Physics and Control*, Potsdam, Germany, September 5, 2007  
– *Condensed-Matter Physics Seminar*, Boston University, Boston, MA, November 17, 2006
- 57 “Coherence preservation via randomized dynamical decoupling”  
Workshop on *Frontiers of Quantum Decoherence*, University of Toronto, Canada, August 13, 2006
- 56 “Quantum dynamical decoupling with unconventional controllers”  
Workshop on *Principles and Applications of Control in Quantum Systems*, Harvard, Cambridge, MA, August 10, 2006
- 55 “Dynamical decoupling methods for coherent quantum control and decoherence suppression”  
Laboratoire Aime Cotton, Orsay, France, June 23, 2006
- 54 “Entanglement as an observer-dependent notion: Entanglement and subsystems, entanglement beyond subsystems, and all that”  
Boston Colloquium for Philosophy of Science on *Foundations of Quantum Information and Entanglement*, Boston University, Boston, MA, March 24, 2006
- 53 “Generalized entanglement as a framework for exploring complex quantum systems”  
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– Workshop on *Theory and Technology in Quantum Information, Communication, Computation, and Cryptography*, ICTP, Trieste, Italy, June 21, 2006  
– *Israel Science Foundation Workshop on Decoherence, Entanglement, and Information in Complex Systems*, Eilat, Israel, February 28, 2006
- 50 “Randomized dynamical decoupling techniques for coherent quantum control”  
XXXVI Winter Colloquium on *The Physics of Quantum Electronics*, Snowbird, UT, January 3, 2006
- 49 “Randomized control of open quantum systems”  
*44th IEEE Conference on Decision and Control & European Control Conference*, Seville, Spain, December 12, 2005
- 48 “On the inevitable relativity of quantum entanglement: What do we know?”  
– *Physics Colloquium*, University of Southern California, Los Angeles, CA, March 20, 2006  
– *Physics Colloquium*, Hunter College, CUNY, New York, NY, April 20, 2005

- 46** “Entanglement as an observer-dependent concept: An application to quantum phase transitions”  
 – *Condensed-Matter Physics Seminar*, University of Massachusetts, Amherst, MA, November 3, 2005  
 – *Institute for Quantum Sciences Seminar*, Michigan State University, Lansing, MI, March 15, 2005  
 – Workshop on *Quantum Entanglement in Physical and Information Sciences*,  
 Scuola Normale Superiore, Pisa, Italy, December 15, 2004
- 43** “Dynamical control of decoherence via active decoupling techniques: Random dynamical decoupling”  
 Workshop on *Quantum Entanglement, Decoherence, Information, and Geometrical Phases in Complex Systems*, ICTP, Trieste, Italy, November 9, 2004
- 42** “Entanglement beyond subsystems”  
 – Second International *Feynman Festival*, College Park, MD, August 20, 2004  
 – *Quantum Information Science Seminar*, MIT, Cambridge, MA, April 20, 2004  
 – *Quantum Information Theory Seminar*, Scuola Normale Superiore, Pisa, Italy, October 27, 2003  
 – *Quantum Information Theory Seminar*, ISI Foundation, Torino, Italy, October 15, 2003  
 – *Quantum Lunch Seminar*, Los Alamos National Laboratory, NM, July 3, 2003  
 – Conference and Workshop on *Coding Theory and Quantum Computing*,  
 University of Virginia, Charlottesville, VA, May 23, 2003
- 36** “Advances in decoherence control”  
 – XXXIV Winter Colloquium on *The Physics of Quantum Electronics*, Snowbird, UT, January 6, 2004  
 – EuroSCO Conference *Quantum Optics: From Fundamental Concepts to Nanotechnology*,  
 Granada, Spain, September 28, 2003
- 34** “Coherent control of quantum dynamics via active decoupling techniques”  
*Quantum Physics Seminar*, University of Michigan, Ann Arbor, MI, February 20, 2003
- 33** “Principles of noise control for quantum information science”  
 – *Physics Colloquium*, Dartmouth College, Hanover, NH, January 24, 2003  
 – *Statistical Mechanics and Complexity Colloquium*, University of Roma “La Sapienza”,  
 Roma, Italy, December 11, 2002
- 31** “Quantum control via dynamical decoupling: Toward robust decoupling schemes”  
*Information Engineering Seminar*, University of Padova, Italy, December 19, 2002
- 30** “Noiseless subsystems, subspaces, and all that: From theory to experiment”  
*Quantum Optics Seminar*, Blackett Laboratory, Imperial College, London, UK, December 5, 2002
- 29** “Principles and demonstrations of noise control in quantum information processing”  
 – First International *Feynman Festival*, College Park, MD, August 26, 2002  
 – International Workshop on *Perspectives in Decoherence Control and Quantum Computing*,  
 Michigan Center for Theoretical Physics, Ann Arbor, MI, August 23, 2002
- 27** “A unified look at quantum noise control in quantum information processing”  
 – *Mathematics Colloquium*, University of Texas at Dallas, Dallas, TX, April 24, 2002  
 – Workshop on *Quantum Entropies: Dynamics and Information*, SISSA-ISAS, Trieste,  
 Italy, December 13, 2001  
 – *Quantum Information Theory Seminar*, ISI Foundation, Torino, Italy, December 5, 2001
- 24** “Theory (and practice) of noiseless quantum subsystems”  
 – Euro-Workshop on *Quantum Computer Theory: In search of viable optimal design*,  
 ISI Foundation, Torino, Italy, June 13, 2001  
 – *Institute for Quantum Information Seminar*, Caltech, Pasadena, CA, April 27, 2001  
 – *Quantum Lunch Seminar*, Los Alamos National Laboratory, NM, April 5, 2001  
 – *Information Physics Seminar*, University of New Mexico, Albuquerque, NM, March 21, 2001  
 – *Research Laboratory for Electronics Seminar*, MIT, Cambridge, MA, March 6, 2001

- 19 “Noise control strategies for quantum information technology”
  - *General Physics Seminar*, University of Roma “La Sapienza”, Roma, Italy, January 9, 2001
  - *Engineering Information Seminar*, University of Padova, Padova, Italy, December 18, 2000
- 17 “On the problem of controlling quantum-mechanical systems – Alias ...  
Controlling and manipulating things on a small scale”  
*Colloquium*, Santa Fe Institute, Santa Fe, NM, November 27, 2000
- 16 “Noiseless subsystems for quantum noise control”  
*Progress in Electromagnetics Research Symposium (PIERS 2000)*, Cambridge, MA, July 13, 2000
- 15 “Quantum noise suppression, noiseless quantum subsystems, and all that”  
*Think-Tank on Computer Science Aspects*, ISI Foundation, Torino, Italy, June 28, 2000
- 14 “Quantum noise control via decoupling”
  - *Physics Seminar Series*, University of Roma “La Sapienza”, Roma, Italy, January 13, 2000
  - *Physics Seminar*, University of Trento, Department of Physics, Trento, Italy, December 17, 1999
  - *Quantum Lunch Seminar*, Los Alamos National Laboratory, Los Alamos, NM, May 21, 1999
- 11 “Decoupling methods for quantum information processing”
  - Gordon Research Conference on *Atomic Physics*, Plymouth State College, NH, July 8, 1999
  - Conference on *Quantum Information Processing and NMR*, Harvard-Smithsonian Center for Astrophysics, Harvard, Cambridge, MA, February 22, 1999
  - *Physics Seminar*, IBM T. J. Watson Research Center, Yorktown Heights, NY, December 8, 1998
- 8 “Decoupling methods for open quantum systems and quantum information”
  - *Physics Colloquium*, Northeastern University, Boston, MA, November 19, 1998
  - *Research Laboratory for Electronics Seminar*, MIT, Cambridge, MA, November 12, 1998
  - *Atomic Physics Seminar Series*, ITAMP, Harvard-Smithsonian Center for Astrophysics, Harvard, Cambridge, MA, October 27, 1998
- 5 “Decoherence control in quantum information processing: Simple models”  
Fourth International Conference on *Quantum Communication, Measurement, and Computing (QCM’98)*, Northwestern University, Evanston, IL, August 23, 1998
- 4 “Open system dynamics and quantum decoherence in trapped ions”  
*University of Padova*, Department of Physics “G. Galilei,” Padova, Italy, April 7, 1997
- 3 “Measurement-induced decoherence in atomic systems”
  - *Quantum Optics Seminar*, Université Pierre et Marie Curie, Paris, France, December 10, 1996
  - *Physics Seminar*, University of Konstanz, Konstanz, Germany, December 5, 1996
- 1 “Markov diffusions in comoving coordinates and stochastic quantization of the free relativistic spinless particle”  
Euroconference *Classical and Quantum evolution: Deterministic and Stochastic*, Bielefeld Germany, July 14, 1995