Hideo Mabuchi Curriculum Vita, June 2008

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Internet: hmabuchi@stanford.edu / www.its.caltech.edu/~hmabuchi/
Date of Birth: October 18, 1971 (United States citizen)

Education *Graduate:* 1998 Ph.D. in Physics, California Institute of Technology
Undergrad: 1992 A.B. in Physics, Magna cum laude, Princeton University

Academic appointments

2007 –	Professor of Applied Physics, Stanford University
2001 –	Associate Professor of Physics and Control & Dynamical Systems, California Institute of Technology *(on leave)*
1998 – 1999	Visiting Fellow in Chemistry, Princeton University
1998 – 2001	Assistant Professor, California Institute of Technology

Selected awards

2006	Institute of Optical Sciences Distinguished Visiting Scientist, University of Toronto
2005	Institute for Systems Research Distinguished Lectureship, University of Maryland
2002	Mohammed Dahleh Distinguished Lectureship, UCSB
2000 – 2005	John D. and Catherine T. MacArthur Foundation Fellowship
2000	Discover Magazine's Twenty Scientists to Watch in the Next Twenty Years
2000 – 2003	Office of Naval Research Young Investigator Award
1999 – 2001	A. P. Sloan Fellowship
1999	Technology Review Magazine's top 100 young innovators

Recent invited talks

2007	(Keynote) Workshop on Noise, Information and Complexity at Quantum Scale, Erice
2007	CLEO-Europe/IQEC Conference (Quantum Optics), Munich
2007	APS/DAMOP Annual Meeting (Quantum Control of AMO Systems), Calgary
2006	8th Int'l Conference on Quantum Communication, Measurement and Computing, Tsukuba
2006	Frontiers in Optics/LS XXII (Optics, Spintronics and Quantum Information), Rochester

Outreach and synergistic activities

Panelist, "The Future of the Universe Science Fiction Film Festival" (1/01, Caltech); Invited participant, "Colloquium on Museums and the Community of Children" (6/01, Children's Museum of Los Angeles); Speaker, Watson Public Lecture Series (11/01, Caltech); Organizing Committee for 8th Annual NAE Symposium on Frontiers of Engineering; Panelist, Los Angeles Philharmonic's *Upbeat Live!* Series (4/02); Greenwall Foundation panel on "Gene Patents, Scientific Inquiry, and the Cultural Imagination" (11/05); Inaugural Chair of the APS Topical Group on Quantum Information, Concepts and Computation (05-06); Scripps College Humanities Core Curriculum External Review Committee (07-08)

Academic service (committees)

Caltech: Physics strategic planning committee; physics graduate admissions (Chair); prize postdoctoral fellowships in experimental physics; undergraduate curriculum committees in physics and in engineering & applied science; physics colloquium; search committees in physics, applied mathematics, information science & technology, and bioengineering; graduate qualifying exams in mechanical engineering and in control & dynamical systems; campus-wide committee on improving teaching quality; biological engineering steering committee

Undergraduate courses

Ph196 **"Introduction to dynamical systems and analytic mechanics"** – I conceived of this course as a way to combine material from advanced undergraduate physics with introductory topics from graduate engineering. We began with the Lagrangian formulation of mechanics, saw how to derive nonlinear differential equations to describe the dynamics of complex systems, and then studied the use of techniques from applied mathematics for qualitative analysis of phase portraits, equilibrium solutions, and bifurcations. Textbooks used include Baruh, Hand & Finch, Perko and Wiggins.

Ph 195 **"Intensive quantum mechanics"** – I conceived of this course as a way to offer the best Caltech undergraduates a more intensive course on basic quantum mechanics in a seminar setting. The basic syllabus was similar to that of Ph 125, but the class size was around twenty rather than eighty. My approach to teaching was to hand out lecture notes ahead of time, together with a set of "discussion problems," and during class time we solved problems together on the board and discussed subtle points of the material. We used my Ph 125 lecture notes as a text.

Ph 125 **"Quantum mechanics"** – This is the core year-long introduction to quantum mechanics for students concentrating in physics. I used lecture notes that I wrote myself as a text. The first quarter sticks with finite-dimensional systems and uses basic quantum information to introduce key concepts. In the second quarter we move on to wave functions and simple scattering problems; in the third quarter we look at applications of symmetry representation theory (simple band structure and angular momentum). Students in third quarter wrote term papers on topics of their choosing.

Ph 12c **"Statistical mechanics"** – This is the third in a three-quarter sequence of courses intended for sophomores who will concentrate in physics. I used the wonderful text by Daniel Schroeder.

CDS 110a **"Introductory control theory"** – This is the core introductory course for undergraduate and graduate engineering students on linear control theory with feedback. I participated as a "consulting faculty member" for several years while Richard Murray developed the course in its current form, and then I taught it last fall on my own. We used a text by Murray and Astrom.

CDS 101 **"Design and analysis of feedback systems"** – This course runs concurrently with CDS 110a; CDS 101 is mainly intended for first-year graduate students in scientific disciplines such as biology and computer science, who want to understand the modern engineering perspective on feedback in complex networks but don't want to bother learning traditional control synthesis methodology.

Graduate courses

AP217 **"Estimation and Control Methods for Applied Physics"** – This was a graduate-level survey class of analysis and design methods from control theory and dynamical systems theory, a mix of material from CDS110a and CDS140a.

Ph 225 **"Advanced quantum mechanics"** – This was a focused graduate seminar on non-commutative (quantum) probability. We used the book "Statistical dynamics" by Streater as a text.

CDS 273 **"Frontiers in control and dynamical systems"** – This is an annual graduate seminar coordinated by Richard Murray and me. We solicit project proposals from faculty members in various fields (ranging from biology to global climate dynamics) to explore the use of control and dynamical systems theory tools in non-traditional application areas. We then match engineering students with students from those disciplines to work together in teams; past projects have led to prize-winning conference presentations and to successful proposals for federal funding.

CDS 140a **"Introduction to dynamics"** – This is a core introductory course on dynamical systems theory for graduate students in the Control and Dynamical Systems and in Mechanical Engineering options. Textbooks used include Perko, Wiggins, and Guckenheimer & Holmes.

Summer projects

2005 Caltech/AFOSR/NSF/ARO "Quantum control summer school" – I was a lecturer and lead organizer. This school brought together about 150 participants from all over the world; its purpose was to build bridges among the physics, engineering and applied mathematics communities interested in quantum filtering and feedback. I secured nearly $100k in funding for the school, coordinated applications and organized the lecturers and program.

2004 Caltech "Computing Beyond Silicon Summer School" – I was a lecturer and the subject coordinator for quantum information science

2003 With Joan Abrahamson of the Jefferson Institute, I coordinated a small meeting on Science & Literature, with novelist Richard Powers, poets Brad Leithauser and Richard Kenney, historian of science Mott Greene, artist Liza Lou, and linguistic anthropologist Elinor Ochs.

2002 Caltech "Computing Beyond Silicon Summer School" – lecturer on quantum information science

2001 Special summer project on "Scientific Creativity and Digital Media," co-sponsored by the USC Multimedia Literacy Project and Caltech's SURF program. In this project I brought together five undergraduate students (two from Caltech and three from abroad) for ten rather intense weeks of work. We started by reviewing the basic theory of quantum-mechanical entanglement and (with the help of a teaching assistant from USC's graduate program in Cinema-Television) also learned about the basics of web design. The students then conceived and executed a project in which they interviewed a number of "professional" physicists (including David Deutsch!) to ask them for a 90-second explanation of entanglement in layman's terms. These interviews were cut down into short sound-bytes, which were then arranged on a chart according to their main themes. This chart was then taken as the spatial map for an interactive, three-dimensional digital "environment" that the students created using Macromedia Flash. The idea was to create a web-based experience incorporating a "non-linear" and circular narrative structure that somehow allegorizes the way physicists think about entanglement. The project was regarded by its participants and sponsors as a great success; early showings of the final product led to the speaking invitations listed below.

Invited lectures on educational themes

2002 2nd John Seely Brown Symposium on Technology and Society, Ann Arbor

2002 Gordon Conference on Research and Education in Physics: Quantum Mechanics, Mt. Holyoke

Teaching awards

2000 Classroom Teaching Award (Graduate Student Council, Caltech)

Articles in preparation (4)

1. "Coherent-feedback quantum control with a dynamic compensator," H. Mabuchi, submitted to Phys. Rev. Lett.
2. "Near-optimal dilute concentration estimation via single-molecule detection," K. McHale, A. J. Berglund and H. Mabuchi, submitted to Optics Express.
3. "Optimal error tracking via quantum coding and continuous syndrome measurement," R. van Handel and H. Mabuchi, submitted to Phys. Rev. Lett.
4. "Derivation of Maxwell-Bloch-type equations by projection of quantum models," H. Mabuchi, to appear in Phys. Rev. A

Publications in refereed journals (67)

5. "Quantum dot photon statistics measured by three-dimensional particle tracking," K. McHale, A. J. Berglund and H. Mabuchi, Nano Lett. **7**, 3535-3539 (2007).
6. "Scattering of polarized laser light by an atomic gas in free space: A quantum stochastic differential equation approach," L. Bouten, J. K. Stockton, G. Sarma and H. Mabuchi, Phys. Rev. A. **75**, 052111 (2007).
7. "Fluctuations in closed-loop fluorescent particle tracking," A. J. Berglund, K. McHale and H. Mabuchi, Opt. Express **15**, 7752-7773, (2007).
8. "Feedback localization of freely diffusing fluorescent particles near the optical shot-noise limit," A. J. Berglund, K. McHale and H. Mabuchi, Opt. Lett. **32**, 145-147 (2007).
9. "Finesse and sensitivity gain in cavity-enhanced absorption spectroscopy of biomolecules in solution,'' T. McGarvey, A. Conjusteau and H. Mabuchi, Opt. Express **14**, 10441-10451 (2006).
10. "Integration of high-Q SiN_x microdisks with magnetostatic atom chips," P. Barclay, K. Srinivasan, O. Painter, B. Lev and H. Mabuchi, Appl. Phys. Lett. **89**, 131108 (2006).
11. "Feedback cooling of atomic motion in cavity QED," D. A. Steck, K. Jacobs, H. Mabuchi, S. Habib and T. Bhattacharya, Phys. Rev. A **74**, 012322 (2006).
12. "Low-lying bifurcations in cavity QED," M. Armen and H. Mabuchi, Phys. Rev. A **73**, 063801 (2006).
13. "Tensor polarizability and dispersive quantum measurement of multilevel atoms," JM Geremia, J. K. Stockton and H. Mabuchi, Phys. Rev. A **73**, 042112 (2006).
14. "Performance bounds on single particle tracking by fluorescence modulation," A. J. Berglund and H. Mabuchi, Appl. Phys. B **83**, 127 (2006).
15. "Tracking-FCS: Fluorescence correlation spectroscopy of individual particles," A. J. Berglund and H. Mabuchi, Optics Express **13**, 8069-8082 (2005).
16. "Principles and applications of control in quantum systems," H. Mabuchi and N. Khaneja, International Journal of Robust and Nonlinear Control **15**, 647-667 (2005).
17. "Modeling and feedback control design for quantum state preparation," R. van Handel, J. K. Stockton, and H. Mabuchi, J. Opt. B: Quantum Semiclass. Opt. **7**, S179-S197 (2005).
18. "Quantum projection filter for a highly nonlinear model in cavity QED," R. van Handel and H. Mabuchi, J. Opt. B: Quantum Semiclass. Opt. **7**, S226-S236 (2005).
19. "Feedback control of quantum state reduction," R. van Handel, J. K. Stockton, and H. Mabuchi, IEEE T. Automat. Contr. **50**, 768 (2005).
20. "Quantum information processing in cavity-QED," S. J. van Enk, H. J. Kimble, and H. Mabuchi, Quantum Information Processing **3**, 75 (2004).

Publications in refereed journals (continued)

21. "Proposed magneto-electrostatic ring trap for neutral atoms," A. Hopkins, B. Lev, and H. Mabuchi, Phys. Rev. A **70**, 053616 (2004).
22. "Deterministic Dicke state preparation with continuous measurement and control," J. K. Stockton, R. van Handel, and H. Mabuchi, Phys. Rev. A **70**, 022106 (2004).
23. "Feasibility of detecting single atoms using photonic bandgap cavities," B. Lev, K. Srinivasan, P. Barclay, O. Painter, and H. Mabuchi, IEEE T. Nanotechnol. **15**, S556 (2004).
24. "Quantum feedback control of atomic motion in an optical cavity," D. A. Steck, K. Jacobs, H. Mabuchi, T. Bhattacharya, and S. Habib, Phys. Rev. Lett. **92**, 223004 (2004).
25. "Bayesian estimation for species identification in single-molecule fluorescence microscopy," K. McHale, A. J. Berglund, and H. Mabuchi, Biophys. J. **86**, 3409 (2004).
26. "Feedback controller design for tracking a single fluorescent molecule," A. J. Berglund and H. Mabuchi, Appl. Phys. B **78**, 653 (2004).
27. "Robust Quantum Parameter Estimation: Coherent Magnetometry with Feedback," J. K. Stockton, JM Geremia, A. C. Doherty, and H. Mabuchi, Phys. Rev. A **69**, 032109 (2004).
28. "Quantum Kalman filtering and the Heisenberg limit in atomic magnetometry," JM Geremia, J. K. Stockton, A. C. Doherty, and H. Mabuchi, Phys. Rev. Lett. **91**, 250801 (2003).
29. "An atom mirror etched from a hard drive," B. Lev, Y. Lassailly, C. S. Lee, A. Scherer, and H. Mabuchi, Appl. Phys. Lett. **83**, 395-397 (2003).
30. "Quantum jumps between dressed states: a proposed cavity-QED test using feedback," J. E. Reiner, H. M. Wiseman, and H. Mabuchi, Phys. Rev. A **67**, 042106 (2003).
31. "Characterizing the entanglement of symmetric many-particle spin-1/2 systems," J. K. Stockton, J. M. Geremia, A. C. Doherty, and H. Mabuchi, Phys. Rev. A **67**, 022112 (2003).
32. "An inverse-problem approach to designing photonic crystals for cavity QED," JM Geremia, J. Williams, and H. Mabuchi, Phys. Rev. E **66**, 066606 (2002).
33. "Programmable logic devices in experimental quantum optics," J. Stockton, M. Armen, and H. Mabuchi, J. Opt. Soc. Am. B **19**, 3019 (2002).
34. "Cavity quantum electrodynamics: coherence in context," (invited review) H. Mabuchi and A. C. Doherty, Science **298**, 1372 (2002).
35. "Exact analysis of concatenated quantum codes," B. Rahn, A. C. Doherty, and H. Mabuchi, Phys. Rev. A **66**, 032304 (2002).
36. "Adaptive homodyne measurement of optical phase," M. A. Armen, J. K Au, J. K. Stockton, A. C. Doherty, and H. Mabuchi, Phys. Rev. Lett. **89**, 133602 (2002).
37. "Photon statistics and dynamics of Fluorescence Resonance Energy Transfer," A. J. Berglund, A. C. Doherty, and H. Mabuchi, Phys. Rev. Lett. **89**, 068101 (2002).
38. "Optimization of Q-factors in microcavities based on free-standing membranes," J. Vuckovic, M. Loncar, H. Mabuchi, and A. Scherer, IEEE J. Quantum Electron. **38**, 850 (2002).
39. "The quantum-classical transition in nonlinear dynamical systems," S. Habib, K. Jacobs, H. Mabuchi, R. Ryne, K. Shizume, and B. Sundaram, Phys. Rev. Lett. **88**, 040402 (2002).
40. "Design of photonic crystal microcavities for cavity QED," J. Vuckovic, M. Loncar, H. Mabuchi, and A. Scherer, Phys. Rev. E **65**, 016608 (2002).

Publications in refereed journals (continued)

41. "Quantum trajectories for realistic detection," P. Warszawski, H. M. Wiseman, and H. Mabuchi, Phys. Rev. A **65**, 023802 (2002).
42. "Quantum networks based on Cavity QED," H. Mabuchi, M. Armen, B. Lev, M. Loncar, J. Vuckovic, H. J. Kimble, J. Preskill, M. L. Roukes, and A. Scherer, Quantum Information and Computation **1**, Special Issue 7-12 (2001).
43. "Robust control in the quantum domain," A. C. Doherty, J. C. Doyle, H. Mabuchi, K. Jacobs, and S. Habib, in Proceedings of the 39th IEEE Conference on Decision and Control (2000).
44. "Sensitivity optimization in quantum parameter estimation," F. Verstraete, A. C. Doherty, and H. Mabuchi, Phys. Rev. A **64**, 032111 (2001).
45. "Ro-vibrational spectroscopy of the v=6 manifold in $^{12}C_2H_2$ and $^{13}C_2H_2$," H. K. Srivastava, A. Conjusteau, H. Mabuchi, A. Callegari, K. K. Lehmann, G. Scoles, M. Silva, and R. W. Field, J. Chem. Phys. **113**, 7376-7383 (2000).
46. "A sub-doppler resolution double resonance molecular beam infrared spectrometer operating at chemically relevant energies (~2 eV)," H. K. Srivastava, A. Conjusteau, H. Mabuchi, A. Callegari, K. K. Lehmann, and G. Scoles, Rev. Sci. Instrum. **71**, 4032-4038 (2000).
47. "Quantum feedback control and classical control theory," A. C. Doherty, S. Habib, K. Jacobs, H. Mabuchi, and S. M. Tan, Phys. Rev. A **62**, 012105 (2000).
48. "Physical Implementations for Quantum Communication in Quantum Networks," H. J. Briegel, J.-I. Cirac, W. Dur, S. J. van Enk, H. J. Kimble, H. Mabuchi, and P. Zoller, Lect. Notes Comput. Sc. **1509**, 373-382 (1999).
49. "Entanglement of Assistance," D. P. DiVincenzo, C. A. Fuchs, H. Mabuchi, J. A. Smolin, A. Thapliyal, and A. Ullman, Lect. Notes Comput. Sc. **1509**, 247-257 (1999).
50. "Full observation of single-atom dynamics in cavity QED," H. Mabuchi, J. Ye, and H. J. Kimble, Appl. Phys. B **68**, 1095-1108 (1999).
51. "Quantum manipulation and measurement of single atoms in optical cavity QED," J. Ye, C. J. Hood, T. Lynn, H. Mabuchi, D. W. Vernooy, and H. J. Kimble, IEEE T. Instrum. Meas. **48**, 608-612 (1999).
52. "Transmission of quantum information in a quantum network: A quantum optical implementation," S. J. van Enk, J. I. Cirac, P. Zoller, H. J. Kimble, and H. Mabuchi, Fortschr. Phys. **46**, 689-695 (1998).
53. "Retroactive quantum jumps in a strongly-coupled atom-field system," H. Mabuchi and H. M. Wiseman, Phys. Rev. Lett. **81**, 4620-4623 (1998).
54. "Atomic localization in optical cavity QED," Q. A. Turchette, M. S. Chapman, C. J. Hood, T. Lynn, H. Mabuchi, and H. J. Kimble, Laser Phys. **8**, 713-717 (1998).
55. "Standard Quantum Limits for broadband measurement," H. Mabuchi, Phys. Rev. A **58**, 123-127 (1998).
56. "High-Q measurements for fused silica microspheres in the NIR," D. W. Vernooy, V. I. Ilchenko, H. Mabuchi, E. W. Streed, and H. J. Kimble, Opt. Lett. **23**, 247-249 (1998).
57. "Quantum communication in a quantum network," J. I. Cirac, S. J. van Enk, P. Zoller, H. J. Kimble, and H. Mabuchi, Phys. Scripta **T76**, 223-232 (1998).
58. "Quantum state transfer in a quantum network – a quantum-optical implementation," S. J. van Enk, J. I. Cirac, P. Zoller, H. J. Kimble, and H. Mabuchi, J. Mod. Opt. **44**, 1727-1736 (1997).

Publications in refereed journals (continued)

59. "Quantum state transfer and entanglement distribution among distant nodes in a quantum network," J. I. Cirac, P. Zoller, H. J. Kimble, and H. Mabuchi, Phys. Rev. Lett. **78**, 3221-3224 (1997).
60. "Real-time detection of individual atoms falling through a high-finesse optical cavity," H. Mabuchi, Q. A. Turchette, M. S. Chapman, and H. J. Kimble, Opt. Lett. **21**, 1393-1395 (1996).
61. "Inversion of quantum jumps in quantum-optical systems under continuous observation," H. Mabuchi and P. Zoller, Phys. Rev. Lett. **76**, 3108-3111 (1996).
62. "Dynamical identification of open quantum systems," H. Mabuchi, Quantum Semiclass. Opt. **8**, 1103-1108 (1996).
63. "Measurement of conditional phase shifts for quantum logic," Q. A. Turchette, C. J. Hood, W. Lange, H. Mabuchi, and H. J. Kimble, Phys. Rev. Lett. **75**, 4710-4713 (1995).
64. "Quantum measurement in quantum optics," H. J. Kimble, O. Carnal, Z. Hu, H. Mabuchi, E. S. Polzik, R. J. Thompson, and Q. A. Turchette, Ann. NY Acad. Sci. **755**, 87-90 (1995).
65. "Blue-light-induced infrared-absorption in $KNBO_3$," H. Mabuchi, E. S. Polzik, and H. J. Kimble, JOSA B **11**, 2023-2029 (1994).
66. "Atom galleries for whispering atoms: binding atoms in stable orbits around an optical resonator," H. Mabuchi and H. J. Kimble, Opt. Lett. **19**, 749-751 (1994).
67. "Quantum nondemolition detection of single photons in an open resonator by atomic beam deflection," A. B. Matsko, S. P. Vyatchanin, H. Mabuchi, and H. J. Kimble, Phys. Lett. A **192**, 175-179 (1994).
68. "Spin transfer between laser-polarized ^{129}Xe nuclei and surface protons," B. Driehuys, G. D. Cates, W. Happer, H. Mabuchi, B. Saam, M. S. Albert, and A. Wishnia, Phys. Lett. A **184**, 88-92 (1993).
69. "Polarization-dependent frequency shifts from Rb-^{3}He collisions," N. R. Newbury, A. S. Barton, P. Bogorad, G. D. Cates, M. Gatzke, H. Mabuchi, and B. Saam, Phys. Rev. A **48**, 558-568 (1993).
70. "Highly polarized muonic He produced by collisions with laser optically pumped Rb," A. S. Barton, P. Bogorad, G. D. Cates, H. Mabuchi, H. Middleton, N. R. Newbury, R. Holmes, J. McCracken, P. A. Souder, J. Xu, and D. Tupa, Phys. Rev. Lett. **70**, 758-761 (1993).
71. "Test of octupole coupled 5^- state in ^{146}Nd using proton inelastic-scattering," P. D. Cottle, M. A. Kennedy, K. W. Kemper, J. D. Brown, E. R. Jacobsen, Y. Y. Sharon, E. M. Leitch, H. Mabuchi, Z. Q. Mao, T. Slivka, and E. J. Greene, Phys. Rev. C **44**, 1668-1671 (1991).

Book chapters

1. "Atoms in microcavities: quantum electrodynamics, quantum statistical mechanics, and quantum information science," A. C. Doherty and H. Mabuchi, in *Optical Microcavities* (World Scientific Press, Singapore, 2004).
2. "Quantum feedback and the quantum–classical transition," H. Mabuchi, in J. D. Barrow, P. C. W. Davies and C. L. Harper, Jr. eds., *Science and Ultimate Reality: Quantum Theory, Cosmology and Complexity* (Cambridge University Press, Cambridge, 2004).

Patents

1. “Photonic crystal microcavities for strong coupling between an atom and the cavity field and method of fabricating the same,” A. Scherer, J. Vuckovic, M. Loncar, and H. Mabuchi (US Patent #6,466,709 B1, issued 15 October 2002).