

## Brian DeMarco

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Dr. Brian DeMarco received his B.A. degree in Physics from the State University of New York at Geneseo in 1996 and his Ph.D. in Physics from the University of Colorado at Boulder in 2001. For his graduate work, DeMarco assembled one of the first experiments to cool  $^{40}\text{K}$  atoms into the ultra-cold regime and subsequently produced the first Fermi gas of atoms. From 2001–2003 DeMarco held a National Research Council post-doctoral fellowship at NIST, where he worked on quantum information experiments using trapped atomic ions with David Wineland.

In 2003 DeMarco joined the Physics Department at the University of Illinois at Urbana-Champaign (UIUC) as an assistant professor, where he started a new effort aimed at realizing quantum simulation using atoms trapped in an optical lattice. This program has been highly successful, resulting in the first observation of the cross-over between quantum tunneling and thermal activation of phase slips (published in *Nature* and featured on the NSF [LiveScience](#) and [Discoveries](#) websites), and the first experimental realization of the disordered Bose-Hubbard model using an optical lattice. Since joining UIUC, DeMarco has been awarded an Office of Naval Research Outstanding Young Investigator Award, an NSF CAREER award, and a Sloan Foundation Research Fellowship. DeMarco also won a first prize at the Amazing Light Symposium worldwide Young Scholars Competition (sponsored by the Templeton Foundation) for young physicists working on “big problems.” DeMarco co-founded the annual Midwestern Cold Atom Workshop and currently serves on as a chair on the DAMOP Program Committee.

## Awards and Honors

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Sloan Foundation Research Fellowship	2006
State University of New York at Geneseo Outstanding Young Alumnus Award	2006
UIUC Center for Advanced Study Beckman Fellow	2006–2007
1 <sup>st</sup> prize in Quantum Physics session at the <i>Amazing Light</i> Young Scholars Competition	2005
National Science Foundation CAREER Award, 2005.	2005
Office of Naval Research Outstanding Young Investigator Award	2004
Michelson Post-doctoral Lectureship Prize, Case Western Reserve University	2003
Atomic, Molecular, or Optical Physics Outstanding Doctoral Thesis Award (DAMOP thesis prize), American Physical Society	2002
National Research Council (NRC) post-doctoral fellowship	2001–2003
JILA Scientific Achievement Award	2000

<i>Science Magazine listed the article <i>Onset of Fermi degeneracy in a trapped atomic gas</i> among the Top Ten Scientific Breakthroughs of 1999</i>	1999
University of Colorado Physics Fellowship	1996–1998

## Invited talks

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<i>Challenges and Opportunities for Cold Atom Quantum Simulation</i>	
Aspen Center for Physics	2009
<i>A New Frontier for AMO Physics: Quantum Simulation</i>	
National Academy of Science / Committee on AMO Science, Washington D.C.	2009
<i>Experiments on Dirty Bosons</i>	
American Physical Society (APS) March Meeting, Philadelphia, PA	2009
APS DAMOP meeting, Charlottesville, VA	2009
JILA theory seminar, Boulder, CO	2009
University of Wisconsin Physics colloquium, Madison, WI	2009
<i>The Ultra-Cold Frontier</i>	
Illinois College convocation series, Jackson, IL	2008
UIUC Osher Lifelong Learning Institute, Urbana, IL	2008
2008 ISAAPT meeting, Urbana, IL	2008
<i>Quantum Degenerate Gases</i>	
DAMOP Graduate Student Symposium, State College, PA	2008
<i>Experiments on transport and disorder in the Bose-Hubbard model</i>	
University of Arizona Optical Sciences Colloquium, Tucson, AZ	2008
UC Berkeley AMO seminar, Berkeley, CA	2008
Yale University condensed matter seminar, New Haven, CT	2008
University of Maryland / JQI seminar, College Park, MD	2008
UT Austin Complex Quantum Systems seminar, Austin, TX	2008
Caltech condensed matter seminar, Pasadena, CA	2008
ICAM Conductor-Insulator Quantum Phase Transitions Workshop, Ohio State University	2008
Summer School on Novel Quantum Phases and Non-equilibrium Phenomena in Cold Atomic Gases, Trieste, Italy	2007
Disorder in Condensed Matter and Cold Atoms, Leiden, Netherlands	2007
University of New Mexico Physics Colloquium, Albuquerque, NM	2007
<i>Observation of Metallic Behavior in an Atomic Bose-Hubbard System</i>	
KITP Program: Strongly Correlated Phases in Condensed Matter and Degenerate Atomic Systems, Santa Barbara, CA	2007
<i>Simulating quantum magnetism (and other Hubbard physics) using optical lattices</i>	
Center for Ultra-Cold Atoms seminar, Cambridge, MA	2007
<i>Simulating quantum magnetism using optical lattices</i>	
Southwest Quantum Information and Technology (SQUINT) Workshop, Pasadena, CA	2007 2007

APS March Meeting, Denver, CA	
<i>Progress toward Quantum Simulation using Ultra-cold atoms</i>	
Canadian Institute for Advanced Research (CIAR) Ultra-cold matter workshop, The Banff Centre, Banff, Canada	2006
<i>What is Absolute Zero?</i>	
UIUC Saturday Honors Physics program, Urbana, IL	2004
<i>Quantum simulation using Ultra-cold atoms</i>	
University of Michigan CM/AMO seminar, Ann Arbor, MI	2005
Amazing Light Symposium, Berkeley, CA	2005
Aspen Center for Physics, Aspen, CO	2005
Optical Society of America, New Laser Scientist Workshop, Rochester, NY	2004
<i>Progress Toward Scalable Trapped Ion Quantum Computing</i>	
Northwestern University quantum optics seminar, Evanston, IL	2004
Argonne National Labs Physics Division seminar, Lemont, IL	2004
University of Toronto physics seminar, Toronto, Canada	2003
Washington State University physics colloquium, Pullman, WA	2003
Optical Society of America Laser Science XIX meeting, Tuscon, AZ	2003
March APS meeting, Austin, TX	2003
<i>An Atomic Abacus: Trapped Ion Quantum Computing Experiments at NIST</i>	
UC Berkeley physics colloquium, Berkeley, CA	2003
New York University physics colloquium, New York, NY	2003
Penn State University Condensed Matter and Atomic and Molecular Physics Symposium, State College, PA	2003
University of Oregon physics colloquium, Eugene, OR	2003
University of Chicago physics colloquium, Chicago, IL	2003
JILA colloquium, Boulder, CO	2003
University of Illinois at Urbana-Champaign quantum information symposium, Urbana, IL	2002
Colorado State University physics colloquium, Fort Collins, CO	2002
<i>Quantum Behavior of an Atomic Fermi Gas</i>	
University of Connecticut Physics colloquium, Storrs, CT	2002
APS DAMOP meeting, Williamsburg, VA	2002
<i>Recent Developments in the NIST Quantum Computing Group</i>	
Quantum Enabled Science and Technology (QUEST) meeting, Santa Fe, NM	2002
<i>Trapped-ion Quantum-state Processing Experiments at NIST</i>	
SQUINT Workshop, Boulder, CO	2002

<i>Quantum Degeneracy in a Fermionic Atom Gas</i> OSA CLEO/QELS meeting	2000
<i>Exploring a Quantum Degenerate Fermi Atom Gas</i> Four Corners meeting of the American Physical Society, Fort Collins, CO	2000
<i>Probing a Quantum Degenerate Gas of Fermionic <math>^{40}\text{K}</math> atoms</i> CNRS workshop on Quantum Degeneracy in Trapped Gases, Gif Sur Yvette, France	2000
Workshop on Multi-Component and Spinor Bose-Einstein Condensates of Trapped Dilute Vapors, ITAMP/Rochester Theory Center, Rochester, NY	1999

## Publications

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- D. McKay, M. White, and B. DeMarco, *Lattice Thermodynamics using Ultra-cold Atoms*, Phys. Rev. A, **79** 063605 (2009).
- M. White, M. Pasienski, D. McKay, S. Zhou, D. Ceperley, and B. DeMarco, *Strongly interacting bosons in a disordered optical lattice*, Phys. Rev. Lett. **102**, 055301 (2009).
- M. Pasienski and B. DeMarco, *A high-accuracy algorithm for designing arbitrary holographic atom traps*, Optics Express **16**, 2176 (2008).
- M. Pasienski and B. DeMarco, *An algorithm for designing high-accuracy arbitrary holographic atom traps*, Proc. SPIE **7038**, 70381D (2008).
- D. McKay, M. White, M. Pasienski, and B. DeMarco, *Phase-slip induced dissipation in an atomic Bose-Hubbard system*, Nature **453**, 76 (2008).
- M. White, H. Gao, M. Pasienski, B. DeMarco, *Bose-Einstein condensates in RF-dressed adiabatic potentials*, Phys. Rev. A **74**, 023616 (2006).
- B. DeMarco, C. Lannert, S. Vishveshwara, and T.-C. Wei, *Structure and stability of Mott-insulator shells of bosons trapped in an optical lattice*, Phys. Rev. A **71**, 063601 (2005).
- R. Ozeri, C. Langer, J. D. Jost, B. DeMarco, A. Ben-Kish, B. R. Blakestad, J. Britton, J. Chiaverini, W. M. Itano, D. B. Hume, D. Leibfried, T. Rosenband, P. O. Schmidt, and D. J. Wineland, *Hyperfine Coherence in the Presence of Spontaneous Photon Scattering*, Phys. Rev. Lett. **95**, 030403 (2005).
- C. Langer, R. Ozeri, J. D. Jost, J. Chiaverini, B. DeMarco, A. Ben-Kish, R. B. Blakestad, J. Britton, D. B. Hume, W. M. Itano, D. Leibfried, R. Reichle, T. Rosenband, T. Schaetz, P. O. Schmidt, and D. J. Wineland, *Long-lived qubit memory using atomic ions*, Phys. Rev. Lett. **95**, 060502 (2005).
- D. Wineland, D. Leibfried, M. Barrett, A. Ben-Kish, J. Bergquist, R. Blakestad, J. Bollinger, J. Britton, J. Chiaverini, B. DeMarco, D. Hume, W. Itano, M. Jensen, J. Jost, E. Knill, J. Koelemeij, C. Langer, W. Oskay, R. Ozeri, R. Reichle, T. Rosenband, T. Schaetz, P.

Schmidt, S. Seidelin, *Quantum Control, Quantum Information Processing, and Quantum-Limited Metrology With Trapped Ions*, Proc. ICOLS (2005).

- T. Schaetz, D. Leibfried, J. Chiaverini, M.D. Barrett, J. Britton, B.L. DeMarco, W.M. Itano, J.D. Jost, C. Langer, and D.J. Wineland, *Towards a scalable quantum computer/simulator based on trapped ions*, Appl. Phys. B **79**, 979 (2004).
- M. D. Barrett, B. DeMarco, T. Schaetz, D. Leibfried, J. Britton, J. Chiaverini, W. M. Itano, B. Jelenković, J. D. Jost, C. Langer, T. Rosenband, and D. J. Wineland, *Sympathetic Cooling of  $^9\text{Be}^+$  and  $^{24}\text{Mg}^+$  for Quantum Logic*, Phys. Rev. A **68**, 042302 (2003).
- D. Leibfried, B. DeMarco, V. Meyer, M. Rowe, A. Ben-Kish, J. Britton, W. M. Itano, B. Jelenković, C. Langer, T. Rosenband and D. J. Wineland, *Experimental Demonstration of a Geometric Phase Gate*, Nature **422**, 412 (2003).
- A. Ben-Kish, B. DeMarco, V. Meyer, M. Rowe, J. Britton, W. M. Itano, B.M. Jelenković, C. Langer, D. Leibfried, T. Rosenband, D.J. Wineland, *Experimental Demonstration of a Technique to Generate Arbitrary Quantum Superposition States of a Harmonically Bound Spin-1/2 Particle*, Phys. Rev. Lett. **90**, 037902 (2003).
- D. Leibfried, B. DeMarco, V. Meyer, A. Ben-Kish, M. Barrett, J. Hughes, W.M. Itano, B.M. Jelenković, C. Langer, D. Lucas, R. Rosenband, and D. J. Wineland, *Towards Quantum Information with Trapped Ions at NIST*, J. Phys. B **36**, 599 (2003).
- D. Leibfried, M.D. Barrett, A. Ben-Kish, J. Britton, J. Chiaverini, B.L. DeMarco, W.M. Itano, B.M. Jelenkovic, J.D. Jost, C. Langer, D. Lucas, V. Meyer, T. Rosenband, M.A. Rowe, T. Schaetz, and D.J. Wineland, *Building Blocks for a Scalable Quantum Information Processor Based On Trapped Ions*, Proc. ICOLS (2003).
- D. Leibfried, B. DeMarco, V. Meyer, A. Ben-Kish, M. Barrett, J. Hughes, W.M. Itano, B.M. Jelenković, C. Langer, D. Lucas, R. Rosenband, and D. J. Wineland, *Quantum Information with Trapped Ions at NIST*, J. Mod. Opt. **50**, 1115 (2003).
- D.J. Wineland, M. Barrett, J. Britton, J. Chiaverini, B. DeMarco, W.M. Itano, B. Jelenković, C. Langer, D. Leibfried, V. Meyer, T. Rosenband, and T. Schatz, *Quantum Information Processing with Trapped Ions*, Philos. T. Roy. Soc. A **361**, 1349 (2003).
- B. DeMarco, A. Ben-Kish, V. Meyer, M. Rowe, J. Britton, W.M. Itano, B.M. Jelenković, C. Langer, D. Leibfried, T. Rosenband and D.J. Wineland, *Experimental Demonstration of a Controlled-NOT Wave-packet Gate*, Phys. Rev. Lett. **89**, 267901 (2002).
- D. Leibfried, B. DeMarco, V. Meyer, M. Rowe, A. Ben-Kish, J. Britton, W. M. Itano, B. Jelenković, C. Langer, T. Rosenband and D. J. Wineland, *Trapped-Ion Quantum Simulator: Experimental Application to Nonlinear Interferometers*, Phys. Rev. Lett. **89**, 247901 (2002).
- M.A. Rowe, A. Ben-Kish, B. DeMarco, D. Leibfried, V. Meyer, J. Britton, W.M. Itano, B. Jelenković, C.Langer, T. Rosenband, and D.J. Wineland, *Transport of Quantum States and Separation of Ions in a Dual RF Ion Trap*, Quant. Info. Compt. **4**, 257 (2002).

- D.J. Wineland, D. Leibfried, B.L. DeMarco, V. Meyer, M.A. Rowe, A. Ben Kish, M. Barrett, J. Britton, J. Hughes, W.M. Itano, B.M. Jelenkovic, C. Langer, D. Lucas and T. Rosenband, *Quantum information processing and multiplexing with trapped ions*, Proc. ICAP (2002).
- B. DeMarco and D.S. Jin, *Spin Excitations in a Fermi Gas of Atoms*, Phys. Rev. Lett. **88**, 040405 (2002).
- J. Goldwin, S.B. Papp, B. DeMarco, and D.S. Jin, *A Two-species Magneto-Optical Trap with  $^{40}\text{K}$  and  $^{87}\text{Rb}$* , Phys. Rev. A **65**, 021402R (2002).
- B. DeMarco, S.B. Papp, and D.S. Jin, *Pauli Blocking of Collisions in a Quantum Degenerate Atomic Fermi Gas*, Phys. Rev. Lett. **86**, 5409 (2001).
- D.S. Jin, B. DeMarco, and S. Papp, *Exploring a Quantum Degenerate Fermi gas*, At. Phys. **551**, 414 (2000).
- M.J. Holland, B. DeMarco, and D.S. Jin, *Evaporative Cooling of a Two Component Fermi Gas*, Phys. Rev. A **61**, 053610 (2000).
- B. DeMarco and D.S. Jin, *Onset of Fermi Degeneracy in a Trapped Atomic Gas*, Science **285**, 1703 (1999).
- B. DeMarco, J. L. Bohn, J. P. Burke, Jr., M. Holland, and D. S. Jin, *Measurement of  $p$ -Wave Threshold Law Using Evaporatively Cooled Fermionic Atoms*, Phys. Rev. Lett. **82**, 4208 (1999).
- B. DeMarco and D.S. Jin, *Exploring a Quantum Degenerate Gas of Fermionic Atoms*, Phys. Rev. A **58**, R4276 (1999).
- B. DeMarco, H. Rohner, and D.S. Jin, *An Enriched  $^{40}\text{K}$  Source for Fermionic Atom Studies*, Rev. Sci. Instrum. **70**, 1967 (1998).

## Funding\*

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<i>Simulation of Frustrated Magnetism and Disorder using Ultra-cold Atoms</i>		
Army Research Office	\$665,520	10/2007–6/2012
<i>Simulating Thermopower in Mott-Hubbard Materials</i>		
National Science Foundation	\$416,360	6/2009–6/2012
<i>Simulating Thermopower in Mott-Hubbard Materials using Optical Lattices</i>		
Office of Naval Research	\$390,000	6/2009–6/2012
<i>Apparatus to simulate thermopower in Mott-Hubbard materials</i>		
Office of Naval Research	\$288,018	4/2009–4/2010
<i>Optimizing Thermopower in Mott-Hubbard Materials</i>		
University of Illinois Research Board	\$21,755	9/2008
<i>CAREER: Quantum Simulation Using Ultra-cold Atom Gases</i>		
National Science Foundation	\$548,099	1/2005–1/2010

### *Quantum Simulation using Ultra-cold Atoms*

University of Illinois Research Board      \$23,375      12/2005

### *Sloan Foundation Fellowship*

Sloan Foundation      \$45,000      9/2006–9/2008

### *Quantum State Control Of An Ultra-cold Atom Gas*

Office of Naval Research      \$297,842      6/2004–5/2007

**\*All are single-investigator grants**

## Teaching

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### Courses taught

College Physics: E&M and Modern (PHYS102) lab coordinator      Fa 2003, Fa 2004\*

*TA coordinator for algebra-based E&M course; also responsible for teaching one lab section*

How Things Work (PHYS140) lecture      Sp 2006, Fa 2006\*, Fa 2007

*Large (600 student, 2-section) lecture course for non-science majors*

How Things Work (PHYS140) administrator / lab coordinator      Fa 2005, Sp 2009

*TA and exam coordinator; course administrator*

Modern Atomic Physics (PHYS598MAP)      Sp 2005\*, Sp 2008

*Graduate elective in modern AMO science; lecture course*

Atomic Physics and Quantum Theory (PHYS485)      Fa 2008\*

*Junior-level, single-semester QM lecture course*

**\*listed among teachers ranked as excellent by their students**

### Courses developed

Modern Atomic Physics (PHYS598MAP / PHYS514)

*Graduate elective in modern AMO science aimed at beginning experiment and theory students in AMO and CM; components include lecture, homework, pre-flight, and final written/oral project; approved as one of several "cafeteria courses" that graduate students can take to fulfill their course requirements*

### Post-doctoral researchers supervised

Hong Gao (2004–2006)

### Ph.D. students supervised

Matthew White (defended 4/7/09), Matthew Pasienski, David McKay, Stanimir Kondov, David Chen William McGehee

## **Undergraduate research assistants supervised**

Sarah Gossett (Sp 2004), Lauren Aycock (Fa 2006–Sp 2008), Matthew Grau (Su 2008), Cecilia Borries (Sp 2009–present)

## **Graduate research independent study**

Minsu Kim (Sp 2004), Matthew Brinkley (Fa 2003–Sp 2004), Cesar Chialvo (Sp 06), Yutaka Miyagawa (Sp 2007)

## **Prelim / dissertation committees**

Evan Jeffrey 12/2/03 (Kwiat), Stephen Gifford 12/3/03 (Baym), Soon Yong Chang 1/26/04 (Pandharipande), Parag Ghosh 8/31/04 (Leggett), Vamsi Akkineni 11/1/04 (Ceperley), Andrea Esler 4/27/05 (Peng), Guojun Zhu 05/09/2005 (Leggett), Bryan Clark 5/9/05 (Ceperley), Alice Abulencia Bridgeman 9/28/05 (Liss), Shizhong Zhang 11/14/05 (Leggett), Guojun Zhu 2/21/05 (Leggett), Zhenhua Yu 2/1/06 (Baym), Onur Hosten 12/21/2006 (Kwiat), Matthew White 12/08/2006 (DeMarco), Ryan Coler 11/2/2007 (Gratton), Kuei Sun 11/05/2007 (Vishveshwara), Brian Ricconi 1/18/2008 (Eden), Matthew Pasienski 02/01/2008 (DeMarco), David McKay 4/25/2008 (DeMarco), Danielle Chandler 04/30/2008 (Schulten), Soheil Baharian 5/9/2008 (Baym), Mohammad Sahrapour 6/3/2008 (Makri), Paul Simonson 4/6/2009 (Clegg), Nicholai Salovich 4/21/2009 (Gianetta), Xu Wang 4/28/2009 (Budakian), Stanimir Kondov 5/1/2009 (DeMarco)

## **Service**

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### **Departmental**

Physics Machine Shop Oversight Committee	2008–present
Physics Library Advisory Committee	2008–present
Physics Machine Shop lab mechanic search committee	2007
AMO faculty position search committee	2007
Undergraduate Academic Advisor (Engineering Physics)	2004–present
Ph.D. Qualifying Exam committee	Sp 2006
Electronics Research Engineer hiring search committee	2006
Quantum Information Science Seminar Co-Chair / Chair	2004–2008 / 2009–present

### **College**

Course approval committee for PHYS522	2008
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## Regional and National

American Physical Society DAMOP Program Committee ultra-cold science and March meeting representation subcommittee / chair	2008–2009/2009–present
NSF Atomic, Molecular, Optical physics proposal review panel	2008
CLEO/QELS 2008 Quantum Optics of Atoms, Molecules, and Solids program subcommittee	2008
Co-organizer of CIAR Quantum Simulation Workshop	2007
Co-founder and co-organizer of Midwestern Cold Atom Workshop	2005–present