

# Dalziel J. Wilson

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## CONTACT INFORMATION

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## RESEARCH INTERESTS

Precision optical and mechanical devices, quantum measurement and control

## EDUCATION

**California Institute of Technology**, Pasadena, CA USA

Ph.D., Physics (2011)

- Dissertation: “Cavity Optomechanics with High-Stress Silicon Nitride Films”
- Advisor: H. Jeff Kimble
- Committee: Oskar Painter, Keith Schwab, and Yanbei Chen

**University of California at Berkeley**, Berkeley, CA USA

*Overall GPA: 3.73/4.00*

B.A., Physics (2005)

- Honors Thesis: “Polarization Pulse Shaping to Control Li<sub>2</sub> Wave Packets”
- Advisor: Stephen R. Leone

B.A., Mathematics (2005)

## HONORS AND AWARDS

International Marie Curie Fellowship (2013-2015)

U.S. Army QuaCGR Fellowship (2007-2011)

University of California at Berkeley: Graduated with Honors in Overall Scholarship (2005)

University of California at Berkeley: Graduated with High Honors in Physics (2005)

University of California at Berkeley: Dean’s List (Fall 2001, Spring 2002)

## ACADEMIC EXPERIENCE

**IBM Research – Zurich**, Rüschlikon, Switzerland

*Visiting Scientist* (May 2018 - present)

*Postdoc* (May 2017 - May 2018)

With Dr. Paul Seidler. Research on optomechanics and non-linear optics with III-V semiconductors. Highlights: First demonstration of microresonator frequency combs in Gallium Phosphide.

**École Polytechnique Fédérale de Lausanne**, Lausanne, Switzerland

*Postdoc* (July 2012 - February 2016, January 2017 - April 2017)

With Prof. Tobias Kippenberg. Research on cavity optomechanics with emphasis on quantum measurement and control. Highlights: displacement measurement efficiency near the uncertainty limit on a mechanical oscillator; feedback-cooling to near the motional ground state, observation of quantum back-action in a room temperature optomechanical system, development of UHQ nanomechanics (first solid state mechanical resonators with  $Q \cdot f \sim 10^{15}$  Hz at room temperature).

**Niels Bohr Institute**, Copenhagen, Denmark

*Visiting Scientist* (March 2012 - June 2012)

With Prof. Eugene Polzik. Developed first cryogenic cavity optomechanics experiment at NBI.

**California Institute of Technology**, Pasadena, CA USA

*Postdoc* (January 2012 - February 2012)

With Prof. H. Jeff Kimble. Research on cavity optomechanics with nanomembranes. Highlights: optical levitation and strong dissipation dilution of a solid state nanomechanical oscillator.

*Graduate Research Assistant* (August 2005 - December 2011)

With Prof. H. Jeff Kimble. Seminal research on cavity optomechanics with nanomembranes, also basic research in atomic physics (see next). Highlights: First quantum coherent mechanical oscillator at room temperature ( $Q \cdot f > 10^{13}$  Hz); demonstration of high-finesse “membrane-in-the-middle” cavity optomechanics; laser cooling of a mechanical oscillator to 100 mK.

*SURF and FSRI Mentor* (2005 - 2010)

Supervised five Caltech “Summer Undergraduate Research Fellows” and one “Freshman Summer Research Intern”. Three projects culminated in undergraduate theses. Topics included mechanical vibration isolation, optical cavity design, laser trapping/cooling, Raman spectroscopy, and optical pumping of Cesium atoms, and characterization of nanomechanical devices.

**University of California at Berkeley**, Berkeley, CA USA

*Undergraduate Research Assistant* (2003 - 2004)

With Prof. Stephen Leone. Undergraduate thesis research: generation and characterization of polarization-shaped ultrafast laser pulses for coherent control of  $\text{Li}_2$  rovibrational wave packets.

*Group Leader, University of California Student Learning Center* (2003 - 2004)

Lectures and study groups for students in entry level physics (classical dynamics).

*Tutor, University of California Student Learning Center* (2002 - 2004)

One-on-one tutoring for students in entry - intermediate level physics (classical dynamics, electromagnetism, thermodynamics, and basic modern physics).

*Undergraduate Research Assistant* (2001)

With Prof. Stephen Boggs. Research on the light curve of Supernova 1987a.

RESEARCH  
HIGHLIGHTS  
(CHRONOLOGICAL)

- First ‘quantum coherent’ mechanical oscillator at room-temperature: a nanomechanical oscillator with a frequency larger than its decoherence rate:  $Q \cdot f > k_B T/h \sim 10^{13}$  [*PRL* 2009].
- Demonstration of high-finesse “membrane-in-the-middle” cavity optomechanics with stressed SiN [*PRL* 2009]: now a widely employed paradigm in contemporary cavity optomechanics.
- Radiation pressure cooling of a solid state nanomechanical oscillator from 300 K to 10 K [*PRL* 2009] and 100 mK [*Ph.D. Thesis* (2012)].
- Optical trapping of a nanomechanical oscillator, establishing a route towards ultra-low-loss optomechanics via levitation [*PRL* 2012], Theory: *PNAS* 2009.

- Demonstration of feedforward cancellation of extraneous thermal noise in a micro-optomechanical system at the level of  $10^{-17}$  m/ $\sqrt{\text{Hz}}$  [*Opt. Exp.* 2012].
- Demonstration of a platform for Heisenberg-Limited readout of nanomechanical motion based on gradient field coupling to an optical microcavity [*PR App.* 2016].
- State-of-the-art low-noise readout of nanomechanical motion [*Nature* 2015]: imprecision 40 dB below that at the SQL and measurement rate approaching the thermal decoherence rate.
- Measurement-based feedback cooling of a solid state mechanical oscillator to near its motional ground state ( $n \sim 5$  phonons) [*Nature* 2015].
- Observation of quantum measurement back-action (radiation pressure shot noise) and strong imprecision-backaction correlations (ponderomotive light squeezing and motional sideband asymmetry) in a feedback-stabilized optomechanical system [*PRX* 2017].
- Observation of radiation pressure shot noise and imprecision-backaction correlations in a room temperature optomechanical system [*PRX* 2017].
- XHQ nanomechanics: Use of strain-engineering to realize solid state mechanical oscillators with unprecedented  $Q$  factors ( $8 \cdot 10^8$ ) and  $Q \cdot f$  product ( $10^{15}$  Hz) at room temperature [*Science* 2018].

REFEREED  
PUBLICATIONS

1. “Elastic Strain Engineering for Ultralow Mechanical Dissipation”  
A. H. Ghadimi, S. A. Fedorov, N. Engelsen, M. Bereyhi, R. Schilling, D. J. Wilson\*, and T. J. Kippenberg  
*Science*, **7.3** 031055 (2018).  
\*corresponding author
  - *Science* News and Views: “Little is Lost”.
2. “Quantum Correlations of Light due to a Room temperature Mechanical Oscillator,”  
V. Sudhir, R. Schilling, S. A. Fedorov, H. Schütz, D. J. Wilson, and T. J. Kippenberg.  
*Physical Review X*, **7.3** 031055 (2017).
3. “Evidence for Structural Damping in a High-Stress Silicon Nitride Nanobeam and its Implications for Quantum Optomechanics,”  
S. A. Fedorov, V. Sudhir, R. Schilling, H. Schütz, D. J. Wilson, and T. J. Kippenberg.  
*Physics Letters A* (2017).
4. “Radiation and Internal-Loss Engineering of High-stress Silicon Nitride Nanobeams,”  
A. H. Ghadimi, D. J. Wilson, and T. J. Kippenberg.  
*Nano Letters* (2017).
5. “Appearance and Disappearance of Quantum Correlations in Measurement-based Feedback Control of a Mechanical Oscillator,”  
V. Sudhir, D. J. Wilson, R. Schilling, H. Schütz, S. A. Fedorov, A. H. Ghadimi, A. Nunnenkamp, and T. J. Kippenberg.  
*Physical Review X*, **7.1** 011001 (2017).
6. “Near-Field Integration of a SiN Nanobeam and a SiO<sub>2</sub> Microcavity for Heisenberg-Limited Displacement Sensing,”  
R. Schilling, H. Schütz, A. Ghadimi, V. Sudhir, D. J. Wilson, and T. J. Kippenberg.  
*Physical Review Applied* **5**, 054019 (2016).

- APS Physics Feature: “Position Detector Approaches the Heisenberg Limit”.

7. “A Strongly Coupled  $\Lambda$ -type Micromechanical System,”  
H. Okamoto, R. Schilling, H. Schütz, V. Sudhir, D. J. Wilson, H. Yamaguchi, and T. J. Kippenberg.  
*Applied Physics Letters* **5**, 054019 (2016).
8. “Measurement-based Control of a Mechanical Oscillator at its Thermal Decoherence Rate,”  
D. J. Wilson, V. Sudhir, N. Piro, R. Schilling, A. Ghadimi, and T. J. Kippenberg.  
*Nature* **524**, 325 (2015).
9. “Enhancement of Mechanical Q-factors by Optical Trapping,”  
K.-K. Ni, R. Norte, D. J. Wilson, J. D. Hood, D. E. Chang, O. J. Painter, and H. J. Kimble.  
*Physical Review Letters* **108**, 214302 (2012).
10. “Suppression of Extraneous Thermal Noise in Cavity Optomechanics,”  
Y. Zhao, D. J. Wilson, K.-K. Ni, and H. J. Kimble.  
*Opt. Exp.* **20**, 3586 (2012).
11. “Cavity Optomechanics using an Optically Levitated Nanosphere,”  
D. E. Chang, C. A. Regal, S. B. Papp, D. J. Wilson, J. Ye, O. Painter, H. J. Kimble, and P. Zoller.  
*Proc. Nat. Acad. Sci.* **107**, 1005 (2009).
12. “Cavity Optomechanics with Stoichiometric SiN Films,”  
D. J. Wilson, C. A. Regal, S. B. Papp, and H. J. Kimble.  
*Phys. Rev. Lett.* **103**, 207204 (2009).
13. “Preparation of a Wave Packet through a Mixed Level in  $\text{Li}_2$ ; Predissociation of One Member of the Superposition,”  
X. Dai, E. A. Torres, E. W. Lerch, D. J. Wilson and S. R. Leone.  
*Chem. Phys. Lett.* **402**, 126 (2005).

#### PREPRINTS

1. “Generalized Dissipation Dilution in Strained Mechanical Resonators”  
S. A. Fedorov, N. J. Engelsen, A. H. Ghadimi, M. J. Beryhi, R. Schilling, D. J. Wilson, and T. J. Kippenberg  
*arXiv:1807.07086* (2018).

#### PRESENTATIONS

- Advanced Photonics Conference, Zurich, Switzerland. July, 2018.  
“Gallium Phosphide Microresonator Frequency Combs” (*Talk*)
- Phonons and PTES 2018 Joint Conference, Nanjing, China. June, 2018.  
“Exploring Quantum Measurement with Nanomechanics and Light” (*Invited Talk, Plenary*)
- IBM Research Seminar, Almaden, CA, USA. May, 2018.  
“Ultra-high Q Mechanical Oscillators in the Spotlight” (*Talk*)
- CLEO Conference, San Jose, USA. May, 2018.  
“Gallium Phosphide Microresonator Frequency Combs” (*Talk*)

SPIE Europe Conference, Strasbourg, France. April, 2018.  
“Gallium Phosphide Nonlinear Photonics” (*Talk*)

Physics Department Colloquium, Pennsylvania State University, USA. March, 2018.  
“Exploring Quantum Measurement with Nanomechanics and Light” (*Invited Talk*)

Physics Department Seminar, University of Oregon, USA. February, 2018.  
“Quantum Optomechanics with Crystalline Membranes” (*Invited Talk*)

Physics Department Colloquium, University of Oregon, USA. February, 2018.  
“Exploring Quantum Measurement with Nanomechanics and Light” (*Invited Talk*)

Optical Sciences College Colloquium, University of Arizona, USA. January, 2018.  
“Exploring Quantum Measurement with Nanomechanics and Light” (*Invited Talk*)

Mechanical Engineering Department Colloquium, EPFL, Switzerland. October, 2017.  
“Quantum coherent nanomechanical resonators see the light” (*Invited Talk*)

Nanomechanics and Nanofluidics Workshop, U. Torino, Italy. September, 2017.  
“Ultra-high-Q nanomechanical resonators through micro-patterning: A lesson in stress management” (*Invited Talk*)

Frontiers in Nanophotonics Conference, Monte Verita, Switzerland. April, 2017.  
“Optomechanical Quantum Correlation Spectroscopy” (*Poster*)

Research Seminar, IBM Zurich, Switzerland. April, 2017.  
“Quantum measurement and control of nanomechanical oscillators” (*Invited Talk*)

CM/AMO Seminar, Columbia University, USA. February, 2017.  
“Quantum measurement and control of nanomechanical oscillators” (*Invited Talk*)

Frontiers in Nanophotonics, Monte Verita, Switzerland. September, 2015.  
“Measurement and control of a mechanical oscillator at its thermal decoherence rate” (*Invited Talk*)

Chalmers Summer School, Hindas, Sweden. June, 2015.  
“Cavity optomechanics: fundamentals and applications” (*Tutorial*)

SpinMechanics 3 Conference, Munich, Germany. June, 2015.  
“Measurement-based control of a mechanical oscillator at its thermal decoherence rate” (*Invited Talk*)

CLEO Conference, San Jose, CA USA. May, 2015.  
“Feedback cooling of a nanomechanical oscillator to near its quantum ground state” (*Talk*)

APS March Meeting, San Antonio, TX USA. March, 2015.  
“Measurement and control of a mechanical oscillator at its thermal decoherence rate” (*Talk*)

CQOM ITN Workshop, Diavolezza, Switzerland. February, 2015.  
“Measurement and control of a mechanical oscillator at its thermal decoherence rate” (*Invited Talk*)

NCCR QSIT General Meeting, Arosa, Switzerland. January, 2015.  
“Measurement and control of a mechanical oscillator at its thermal decoherence rate” (*Invited Talk*)

WE Haraeus Seminar, Bad Honnef, Germany. December, 2014.  
“Measurement and control of a mechanical oscillator at its thermal decoherence rate” (*Poster*)

Quantum Science and Technology (QSIT) Seminar, ETH Zurich, Switzerland. October, 2014.

“Measurement and control of a mechanical oscillator at its thermal decoherence rate” (*Invited Talk*)  
International Conference of Near Field Optics, Snowbird, UT USA. September, 2014.  
“Measurement and control of a mechanical oscillator at its thermal decoherence rate” (*Invited Talk*)

International Conference of Atomic Physics, Washington, DC USA. August, 2014.  
“Feedback cooling of a nanomechanical oscillator using a near-Heisenberg-limited position measurement” (*Poster*)

Gordon Research Conference on Mechanical Systems in the Quantum Regime, Ventura, CA USA. March, 2014.  
“Near-field optomechanical system with ultra-high cooperativity” (*Poster*)

CIFAR - Quantum Cavities Workshop, Montreal, Canada. May, 2013.  
“Coherent coupling of light and two-level defects with mechanical oscillators” (*Poster*)

EPFL Photonics Summer School, Lausanne, Switzerland. September, 2013.  
“Cavity optomechanics with whispering gallery mode microresonators” (*Tutorial*)

Quantum Systems and Technology Conference, Monte Verita, Switzerland. July, 2013.  
“Hybrid on-chip opto-nanomechanical transducer” (*Poster*)

cQOM ITN Workshop, Diavolezza, Switzerland. February, 2013.  
“Cavity optomechanics with high stress silicon nitride films” (*Invited Talk*)

Winter Colloquium on the Physics of Quantum Electronics, Snowbird, UT USA. January, 2013.  
“Quantum-coherent coupling of light to mechanical motion” (*Invited Talk*)

Gordon Research Conference on Mechanical Systems in the Quantum Regime, Galveston, TX USA. March, 2012.  
“Suppression of extraneous thermal noise in a cavity optomechanical system” (*Poster*)

Center for Exotic Quantum Systems Seminar, Caltech, Pasadena, CA USA. September, 2010.  
“Optomechanics with SiN films at 300 K” (*Invited Talk*)

Next Generation Photonics Symposium, Caltech, Pasadena, CA USA. February, 2010.  
“Optomechanics with stoichiometric SiN films” (*Invited Talk*)

Gordon Research Conference on Mechanical Systems in the Quantum Regime, Galveston, TX USA. March, 2010.  
“Optomechanics with stoichiometric SiN films” (*Poster*)

Gordon Research Conference on Atomic Physics, Tilton, NH USA. June, 2009.  
“Cavity optomechanics with stoichiometric SiN films” (*Poster*)

International Conference on Atomic Physics, University of Connecticut, CN USA. July, 2008.  
“Coherent control of one atom strongly coupled to an optical cavity” (*Poster*)