

# MATTHEW DUK-YING LEW

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## EDUCATION

- Ph.D. in Electrical Engineering, 4.0 GPA** 2010 – 2015  
Stanford University, Stanford, CA  
Research Advisor: Professor W. E. Moerner  
Thesis Title: “Engineering New Capabilities into Optical Microscopes: Toward Measuring the Three-Dimensional Position and Orientation of Single Molecules in Living Cells”
- M.S. in Electrical Engineering, 3.9 GPA** 2010  
Stanford University, Stanford, CA
- B.S. with Honor in Electrical Engineering, 4.0 GPA** 2008  
California Institute of Technology, Pasadena, CA  
Research Advisor: Professor Changhuei Yang  
Thesis Title: “Quantitative Differential Phase Imaging and Phase Reconstruction based on the Interference Pattern of a Four-Hole Aperture”

## ACADEMIC APPOINTMENTS

- Assistant Professor** 2015 – present  
Preston M. Green Department of Electrical and Systems Engineering, Washington University in St. Louis, MO
- Postdoctoral Scholar** 2014 – 2015  
de la Zerda Group, Department of Structural Biology, Stanford University School of Medicine, Stanford, CA

## AWARDS AND RECOGNITIONS

- National Science Foundation CAREER Award 2017-2022
- Hiruma/Wagner Award, *16<sup>th</sup> Conference of Peace through Mind/Brain Science* 2016
- Winner of 2015 After Image Photo Contest, *Optics & Photonics News* 2015
- Second Place Poster Award, Gordon Research Conferences: Single-Molecule Approaches to Biology 2012
- Stanford Bio-X Travel Award 2010, 2011
- PicoQuant Young Investigator Award 2010
- National Science Foundation Graduate Research Fellowship 2008
- Newport-Spectra Physics Research Excellence Award 2008
- Stanford Graduate Fellowship, 3Com Corporation Fellow 2008
- Tau Beta Pi Fellow No. 762 2008
- Caltech Carnation Merit Award 2007
- Caremark Rx Scholarship 2006, 2007
- Tau Beta Pi Scholarship 2007
- Caltech Summer Undergraduate Research Fellowship, Rita A. and Øistein Skjellum Fellow 2006

Caltech Peripall Speaking Competition Finalist	2006
College Board National Advanced Placement Scholar	2004
MasterCard Alamo Bowl Scholarship	2004
National Merit Scholarship	2004

## RESEARCH EXPERIENCE

**Research Intern** 2014  
Google[x], Mountain View, CA

**Graduate Researcher** 2009 – 2014  
Moerner Lab, Stanford University, Stanford, CA  
Three-dimensional (3D) super-resolution microscopy of biological structures using single-molecule fluorescent probes. Design of novel point spread functions for measuring the 3D position of nanoscale objects. Development of analytical tools for precise and accurate measurement of 3D position and orientation of single fluorescent molecules.

**Undergraduate Researcher** 2006 – 2008  
Biophotonics Laboratory, California Institute of Technology, Pasadena, CA  
Simulated, characterized, and optimized the design of a novel lensless chip-based device to perform quantitative differential interference contrast microscopy.

## TEACHING EXPERIENCE

**Assistant Professor** 2015 – present  
Preston M. Green Department of Electrical and Systems Engineering, Washington University in St. Louis, MO  
Designing and teaching new course, ESE 582 “Fundamentals and Applications of Modern Optical Imaging.”

**Course Designer and Lecturer** 2012  
Stanford University, Stanford, CA  
Co-designed lecture, homework, laboratory, and syllabus content for “Introduction to Photonics” with Professor Audrey Ellerbee. Integrated active learning exercises into lecture materials in order to spark student motivation, facilitate connection of content to students’ prior knowledge, and expose possible student misconceptions. Taught one week of lectures on wave optics.

**Teaching Assistant** 2006 – 2008  
California Institute of Technology, Pasadena, CA  
Served as teaching assistant for “Electronics Laboratory” and “Feedback and Control Circuits” courses. Held office hours, assisting students with both theoretical and lab-related questions, and graded homework and lab exercises.

## PROFESSIONAL EXPERIENCE

**Program Committee, Stanford University Photonics Retreat (SUPR) 2015** 2015  
Asilomar Conference Grounds, Pacific Grove, CA

**Co-President, Stanford Optical Society, Student Chapter of OSA and SPIE** 2013 – 2014  
Stanford University, Stanford, CA  
-- Recipient of The Optical Society’s 2014 Student Chapter Excellence Award

<b>Program Committee, SUPR 2014</b> Marconi Conference Center, Marshall, CA	2014
<b>Program Chair, SUPR 5</b> DoubleTree Hotel Sonoma Wine Country, Rohnert Park, CA	2013
<b>Program Committee, SUPR 2012</b> Asilomar Conference Grounds, Pacific Grove, CA	2012
<b>Program Committee, International OSA Network of Students (IONS) North America-3</b> Stanford University, Stanford, CA	2012
<b>Co-Mentor for Bing Undergraduate Summer Research Fellowship in Chemistry</b> Stanford University, Stanford, CA	2010
<b>President, California Beta Chapter, Tau Beta Pi</b> California Institute of Technology, Pasadena, CA	2007 – 2008
<b>Vice Chair, Caltech Chapter, IEEE</b> California Institute of Technology, Pasadena, CA	2007 – 2008
<b>Student Engineer</b> Southwest Research Institute, San Antonio, TX	2004 – 2005

## PUBLICATIONS

[h-index: 14](#), [i10-index: 15](#), \*equal contribution, †cover article

### Refereed Journal Publications

13. O. Liba, **M. D. Lew**, E. D. SoRelle, R. Dutta, D. Sen, D. M. Moshfeghi, S. Chu, and A. de la Zerda, "Speckle-modulating optical coherence tomography in living mice and humans." *Nat. Commun.* **8**, 15845 (2017).
12. † A. von Diezmann, M. Y. Lee, **M. D. Lew**, and W. E. Moerner, "Correcting field-dependent aberrations with nanoscale accuracy in three-dimensional single-molecule localization microscopy." *Optica* **2**, 985 (2015).
11. **M. D. Lew** and W. E. Moerner, "Azimuthal polarization filtering for accurate, precise, and robust single-molecule localization microscopy." *Nano Lett.* **14**, 6407 (2014).
10. A. S. Backer, M. P. Backlund, **M. D. Lew**, and W. E. Moerner, "Single-molecule orientation measurements with a quadrated pupil." *Opt. Lett.* **38**, 1521 (2013).
9. † **M. D. Lew\***, M. P. Backlund\*, and W. E. Moerner, "Rotational mobility of single molecules affects localization accuracy in super-resolution fluorescence microscopy." *Nano Lett.* **13**, 3967 (2013).
8. M. P. Backlund\*, **M. D. Lew\***, A. S. Backer, S. J. Sahl, G. Grover, A. Agrawal, R. Piestun, and W. E. Moerner, "Simultaneous, accurate measurement of the 3D position and orientation of single molecules." *Proc. Natl. Acad. Sci. USA* **109**, 19087 (2012).  
-- Featured in *Nat. Methods* **10**, 13 (2013): "Methods in Brief."
7. † H-L. D. Lee\*, S. J. Sahl\*, **M. D. Lew**, and W. E. Moerner, "The double-helix microscope super-resolves extended biological structures by localizing single blinking molecules in three dimensions with nanoscale precision," *Appl. Phys. Lett.* **100**, 153701 (2012).
6. **M. D. Lew\***, S. F. Lee\*, J. L. Ptacin, M. K. Lee, R. J. Twieg, L. Shapiro, and W. E. Moerner, "Three-dimensional superresolution colocalization of intracellular protein superstructures and the cell surface in live *Caulobacter crescentus*," *Proc. Natl. Acad. Sci. USA* **108**, E1102 (2011).
5. **M. D. Lew**, S. F. Lee, M. Badiestostami, and W. E. Moerner, "Corkscrew point spread function for far-field three-dimensional nanoscale localization of pointlike objects," *Opt. Lett.* **36**, 202 (2011).

4. M. Badieirostami, **M. D. Lew**, M. A. Thompson, and W. E. Moerner, "Three-dimensional localization precision of the double-helix point spread function versus astigmatism and biplane," *Appl. Phys. Lett.* **97**, 161103 (2010).
3. M. A. Thompson\*, **M. D. Lew\***, M. Badieirostami, and W. E. Moerner, "Localizing and tracking single nanoscale emitters in three dimensions with high spatiotemporal resolution using a double-helix point spread function," *Nano Lett.* **10**, 211 (2010).
2. X. Cui, **M. Lew**, and C. Yang, "Quantitative differential interference contrast microscopy based on structured-aperture interference," *Appl. Phys. Lett.* **93**, 091113 (2008).
1. **M. Lew**, X. Cui, X. Heng, and C. Yang, "Interference of a four-hole aperture for on-chip quantitative two-dimensional differential phase imaging," *Opt. Lett.* **32**, 2963 (2007).

#### Review Articles and Book Chapters

3. **M. D. Lew**, S. F. Lee, M. A. Thompson, H-L. D. Lee, and W. E. Moerner, "Single-molecule photocontrol and nanoscopy," in *Far-Field Optical Nanoscopy* (eds. P. Tinnefeld, C. Eggeling, and S. W. Hell) **14**, 87 (Springer-Verlag, 2015).
2. M. P. Backlund, **M. D. Lew**, A. S. Backer, S. J. Sahl, and W. E. Moerner, "The role of molecular dipole orientation in single-molecule fluorescence microscopy and implications for super-resolution imaging," *ChemPhysChem* **15**, 587 (2014).
1. M. A. Thompson, **M. D. Lew**, and W. E. Moerner, "Extending microscopic resolution with single-molecule imaging and active control," *Annu. Rev. Biophys.* **41**, 321 (2012).

#### Other Publications

7. A. S. Backer, M. P. Backlund, **M. D. Lew**, A. R. Diezmann, S. J. Sahl, and W. E. Moerner, "Single-molecule orientation measurements with a quadrated pupil," *Proc. SPIE* **8950**, 89500L (2014).
6. **M. D. Lew\***, A. R. S. von Diezmann\*, and W. E. Moerner, "Easy-DHPSF open-source software for three-dimensional localization of single molecules with precision beyond the optical diffraction limit," *Protocol Exchange* (2013). DOI: 10.1038/protex.2013.026
5. M. P. Backlund\*, **M. D. Lew\***, A. S. Backer, S. J. Sahl, G. Grover, A. Agrawal, R. Piestun, and W. E. Moerner, "The double-helix point spread function enables precise and accurate measurement of 3D single-molecule localization and orientation," *Proc. SPIE* **8590**, 85900L (2013).
4. **M. D. Lew**, M. A. Thompson, M. Badieirostami, and W. E. Moerner, "In vivo three-dimensional superresolution fluorescence tracking using a double-helix point spread function," *Proc. SPIE* **7571**, 75710Z (2010).
3. **M. Lew**, X. Cui, X. Heng, and C. Yang, "Two-dimensional differential interference contrast microscopy based on four-hole variation of Young's interference," *Proc. SPIE* **6859**, 685916 (2008).
2. X. Cui, **M. Lew**, X. Heng, and C. Yang, "On-chip differential interference contrast (DIC) phase imager and beam profiler based on Young's interference," *Proc. SPIE* **6441**, 64411F (2007).
1. **M. Lew**, X. Cui, and C. Yang, "Measuring the phase of light," *Caltech Undergraduate Research Journal* **6**, 18 (2007).

## PATENTS

2. O. Liba, **M. D. Lew**, E. D. SoRelle, and A. De La Zerda, inventors; The Board of Trustees of the Leland Stanford Junior University, assignee. "Methods and Apparatus for Speckle-Free Optical Coherence Imaging," International Patent Application PCT/US 2016/057656 (2016).
1. **M. D. Lew** and W. E. Moerner, inventors; The Board of Trustees of the Leland Stanford Junior University, assignee. "Apparatus and method for localizing objects for distance and/or in three dimensions using a spiral point spread function," United States Patent Application US 2013/0147925 (2012).

## ORAL PRESENTATIONS

### Invited

14. "Computational Optics for Imaging Nanoscale Single-Molecule Dynamics," *Washington University in St. Louis Chemistry Seminar*, St. Louis, MO, March 2017.
13. "Single molecules and computational optics for nanoscale biological imaging," *Washington University in St. Louis Optical Radiology Seminar*, St. Louis, MO, October 2016.
12. "Single molecules and computational optics for nanoscale biological imaging," *Washington University in St. Louis Biochemistry and Molecular Biophysics Seminar*, St. Louis, MO, March 2016.
11. "Single molecules and computational optics for nanoscale imaging of living cells," *The Sixteenth Conference of Peace through Mind Brain Science*, Hamamatsu City, Japan, February 2016.
10. "Single molecules and computational optics for nanoscale imaging of living cells," *Washington University in St. Louis Biomedical Engineering Seminar*, St. Louis, MO, February 2016.
9. "Accurate 3D nanoscale imaging of dipole-like emitters," *Laser Science 2015*, San Jose, CA, October 2015.
8. "Accurate nanoscale imaging of dipole-like emitters," *Stefan W. Hell group retreat*, Ringberg Castle, Kreuth, Germany, January 2015.
7. "Engineering new capabilities into optical microscopes: towards measuring the 3D position and orientation of biomolecules within living cells," *Washington University in St. Louis Electrical and Systems Engineering Seminar*, St. Louis, MO, April 2014.
6. "Beyond the clear pupil: engineering new capabilities into optical microscopes," *Washington University in St. Louis Electrical and Systems Engineering Seminar*, St. Louis, MO, March 2014.
5. "Beyond the clear pupil: engineering new capabilities into optical microscopes," *Duke University Electrical and Computer Engineering Seminar*, Durham, NC, March 2014.
4. "Beyond the clear pupil: engineering new capabilities into optical microscopes," *IBM Research Almaden ARC Angels Student Seminar Series*, San Jose, CA, February 2014.
3. "Superresolution far-field optical microscopy: turning mountains into points," *Spectra-Physics company seminar*, Santa Clara, CA, November 2011.
2. "Three-dimensional superresolution fluorescence microscopy using a double-helix point spread function," *Arizona State University Center for Biological Physics Graduate Seminar*, Tempe, AZ, November 2011.
1. "In vivo three-dimensional superresolution fluorescence tracking using a double-helix point spread function," *SPIE Photonics West BiOS (Biomedical Optics)*, San Francisco, CA, January 2010.

### Contributed

13. "An azimuthal polarizer assures localization accuracy in single-molecule super-resolution fluorescence microscopy," *OSA CLEO: 2015*, San Jose, CA, May 2015.
12. "Optical methods for measuring single-molecule orientation and position: implications for super-resolution microscopy," *OSA Frontiers in Optics (FiO)*, Orlando, FL, October 2013 (postdeadline).
11. "Measuring the 3D position and orientation of single molecules simultaneously and accurately with the double helix microscope," *OSA CLEO: 2013*, San Jose, CA, June 2013.
10. "The double-helix microscope simultaneously measures single-molecule orientation and 3D position, reducing dipole-induced localization errors," *Understanding Cell Behavior through Single Cell and Single Molecule Biology: Conference on Quantitative Bioimaging*, Albuquerque, NM, January 2013.
9. "The double-helix microscope simultaneously measures single-molecule orientation and 3D position, reducing dipole-induced localization errors," *Gordon Research Conferences: Single-Molecule Approaches to Biology*, West Dover, VT, July 2012 (2<sup>nd</sup> place poster award).
8. "Superresolution double-helix microscopy resolves extended biological superstructures in 3D within bacterial and mammalian cells," *Stanford Molecular Biophysics Seminar*, Stanford, CA, April 2012.
7. "Super-resolution 3D co-localization of protein superstructures and the cellular surface in live *Caulobacter crescentus*," *OSA FiO*, San Jose, CA, October 2011.

6. "Super-resolution 3D co-localization of protein superstructures and the cellular surface in live *Caulobacter crescentus*," *International OSA Network of Students-North America 3 (IONS-NA3)*, Stanford, CA, October 2011.
5. "Three-dimensional super-resolution imaging with a corkscrew point spread function," *OSA Novel Techniques in Microscopy*, Monterey, CA, April 2011.
4. "Three-dimensional super-resolution co-localization of intracellular protein superstructures and the cell membrane in live *Caulobacter crescentus*," *3<sup>rd</sup> Annual Center for Biological Imaging at Stanford Symposium*, Stanford, CA, March 2011.
3. "Three-dimensional superresolution imaging of single emitters using a double-helix point spread function," *Picoquant 16<sup>th</sup> Annual Workshop on Single Molecule Spectroscopy and Ultrasensitive Analysis in the Life Sciences*, Berlin, Germany, September 2010.
2. "Localization precision of three-dimensional superresolution fluorescence imaging using a double-helix point spread function," *OSA Computational Optical Sensing and Imaging*, San Jose, CA, October 2009.
1. "Two-dimensional differential interference contrast microscopy based on four-hole variation of Young's interference," *SPIE Photonics West BIOS*, San Jose, CA, January 2008.

## PROFESSIONAL MEMBERSHIPS

American Chemical Society	2015 – present
The Optical Society	2008 – present
SPIE	2007 – 2015
Tau Beta Pi	2007 – present